RESULTS OF AIR EMISSION TESTS DURING THE WASTE-TO-ENERGY DEMONSTRATION PROGRAM AT THE COMMERCE REFUSE-TO-ENERGY FACILITY

VOLUME 1. TECHNICAL REPORT

Prepared for:

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Tustin, California

DECEMBER 1988

ESR 20534-6

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REPORT CERTIFICATION

The sampling and analysis performed for this report was carried out under my direction and supervision.

Date 12/13/88

Mark D. McDannel

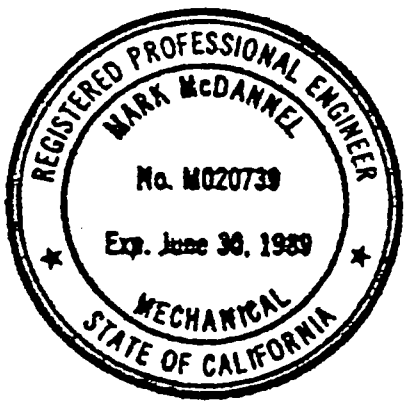
M. D. McDannel, P.E., Manager, Air Quality Services

I have reviewed all testing details and results in this test report and hereby certify that the test report is authentic and accurate.

Date 12/13/88

Mark D. McDannel

M.D. McDannel, P.E., Manager, Air Quality Services



SECTION 1.0

INTRODUCTION AND SUMMARY

Energy Systems Associates (ESA) was contracted by the Los Angeles County Sanitation Districts (LACSD) to perform a set of emission tests at the Commerce Refuse-to-Energy facility as part of the Waste-to-Energy Demonstration Program (WTEDP). The WTEDP is a large-scale program funded by the State of California under the direction of the California Waste Management Board (CWMB). The purpose of the program was to fully characterize the incoming waste stream, air emissions, and ash residue from a state-of-the-art waste-to-energy facility.

ESA's involvement in the project consisted of determining the emission rate of criteria and noncriteria pollutants at the boiler exit and stack of the Commerce facility. The tests were performed from July 18 through August 5, 1988, in parallel with similar tests performed by the California Air Resources Board (CARB). The air tests were intended to provide data to meet the following objectives:

1. Characterize emissions from the Commerce facility while firing commercial refuse and while firing a mix of residential and commercial refuse.

2. Characterize pollution control equipment performance.

3. Provide additional emissions data requested by the South Coast Air Quality Management District (SCAQMD) which includes emission data for use in a Health Risk Assessment of the Commerce Facility.

The facility is currently operating under a Permit to Construct issued by the SCAQMD, Application Numbers 103649, 103650, 103653, 103656, 120137, and 120162.

The test program consisted of two complete sets of measurements of criteria and non criteria pollutants at the boiler exit and at the stack. One set of measurements was conducted while firing a fuel mix consisting of about 60% commercial and 40% residential waste intended to simulate a typical municipal solid waste (MSW) mix, and one set was conducted while burning primarily commercial fuel which consisted of about 95% commercial refuse and 5% residential refuse. The refuse normally fired at the Commerce facility is the 95/5 mix; the residential refuse necessary to make the 60/40 mix was brought in only for the purpose of these tests.

The criteria pollutants measured included NO_x, SO_x, CO, HC, and total particulate. Noncriteria pollutant tests included dioxins/furans, other semi-volatile organic species, metals, trace volatile organic species, formaldehyde, nitrosamines, and acid gases.

The ESA test team was supervised by Mark D. McDannel, P.E. Frank Caponi served as project manager for LACSD and coordinated all efforts of the program. Emmanuel Ruivivar and Mohsen Nazemi of the SCAQMD witnessed portions of the tests.

The results of the tests are summarized in Tables 1-1 and 1-2. Table 1-1 presents the emission results of the criteria pollutant tests and Table 1-2 presents the results of the noncriteria pollutant tests. Table 1-3 presents a summary of the removal efficiency of the spray dryer/baghouse system on criteria and noncriteria pollutants. Detailed results are included in Section 4.0.

TABLE 1-1.
SUMMARY OF CRITERIA POLLUTANT EMISSIONS,
COMMERCE REFUSE-TO-ENERGY FACILITY, 1988

Species	Mixed Fuel	Commercial Fuel	SCAQMD Emission Units Limit	SCAQMD Emission Units Rule No.
NOx*: ppm at 3% O_2	144	134	225	476
lb/hr	36.4	35.8	41	permit
SOx: ppm at 3% O_2	1.6	4.9	500	407
lb/hr	0.9	1.7	9	permit
CO*: ppm at 3% O_2	36	26	2,000	407
lb/hr	5.5	4.1	18	permit
HC by TCA/FID**: ppm at 3% O_2	12	9		
lb/hr	1.09	0.84	3	permit
Total Particulate:				
gr/dscf at 12% CO_2	0.0050	0.0066		
gr/dscf at 3% O_2	0.0063	0.0086	0.01	476
lb/hr	1.85	2.53	11	476
			5.5	permit
Solid Particulate, lb/hr	0.52	0.28		

* Data presented are for the compliance runs performed according to strict EPA test procedures. Additional NO_x and CO data for all tests are presented in Table 4-4.

** Results for condensible hydrocarbons are considered invalid due to interferences, so only volatile hydrocarbon values are presented. See Section 4.2.1 for discussion.

TABLE 1-2. SUMMARY OF NON-CRITERIA POLLUTANT EMISSIONS, COMMERCE REFUSE-TO-ENERGY FACILITY, 1988

	Mixed Fuel	Commercial Fuel
Total PCDD/PCDF: ng/Nm^3 at 12% CO_2	1.94[1] 10.72[2]	3.26
PCDD/PCDF Toxic Equivalent by CA DOHS: ng/Nm^3 at 12% CO_2	0.17[1] 0.36[2]	0.22
Total PAH, ug/Nm^3 at 12% CO_2:		
excluding naphthalene[3]	<0.15	<.095
including naphthalene	<0.47	<1.3
Total PCB, ug/Nm^3 at 12% CO_2:	ND<0.385	<0.093
Chlorobenzenes and chlorophenols: ug/Nm^3 at 12% CO_2	ND <1.8	<2.8
Total Chlorinated HC, ppb	<1.2	<1.0
Metals, ug/Nm^3 at 12% CO_2:		
Arsenic	<0.16	<0.08
Beryllium	<0.19	<0.17
Cadmium	2.0	0.4
Chromium	2.4	<0.3
Lead	2.0	3.2
Mercury	41	76
Nickel	6.3	<0.28
Formaldehyde, ppm at 3% O_2	---	0.12
Nitrosamines, ug/Nm^3 at 12% CO_2	ND<8.1	ND<3.9
HCl, ppm at 3% O_2	9.4	7.0
HF, ppm at 3% O_2	0.074	0.087

NOTES:

1. Excluding Test 1, which was conducted at reduced load and during combustion upset conditions
2. Including Test 1
3. Measured naphthalene levels were high for test samples and blanks due to interferences

TABLE 1-3. REMOVAL EFFICIENCY OF SPRAY DRYER/BAGHOUSE SYSTEM

	Mixed Refuse	Commercial Refuse
Total Particulate	99.77	99.49
Solid Particulate	99.93	99.94
SO_x	98.3	97.2
Total PCDD/PCDF	99.77	99.62
PAH*	>99.39	>97.48
PCB	Not detected at boiler exit or stack	
Chlorobenzenes	Not detected at boiler exit or stack	
Chlorophenols	Not detected at boiler exit or stack	
Metals:		
Arsenic	>99.8	>99.9
Beryllium	>97.2	>95.5
Cadmium	99.88	99.96
Chromium (metals train)	99.93	>99.95
Lead	99.99	99.98
Mercury	91.3	73.6
Nickel	99.85	>99.987
HCl	98.9	99.0
HF	98.8	98.9

* Not including naphthalene

SECTION 2.0

UNIT DESCRIPTION AND OPERATION

The Commerce Refuse-to-Energy facility consists of a municipal solid waste (MSW) fired boiler with a nominal capacity of 380 tons per day refuse charging rate and 115,000 lb/hr steam flow rate. The steam is used to generate 10 MW of electricity for sale to Southern California Edison.

Air pollutant control is achieved by a number of techniques. NO_x emissions are controlled by combustion control and NH_3 injection into the furnace exist gas (Thermal $DeNO_x$). Acid gas (SO_2 and HCl) control is achieved by a Teller/AAF spray dryer, which utilizes lime to collect the acid gases. Particulate control is by an American Air Filter baghouse.

The facility is base loaded, so its design operation is at full capacity 24 hours per day.

The unit normally operates on refuse generated within the City of Commerce. Approximately 95% of this refuse is from commercial sources. Commercial refuse tends to be drier and have a higher heating content than residential refuse. For this program, tests were performed on the normal refuse mix and on a mixture targeted to be 60% residential and 40% commercial refuse.

Unit operation during the tests is summarized in Table 2-1. A more detailed breakdown of plant operating data during the tests is provided as an appendix. Boiler operation was stable and within normal bounds for all tests, with the exception of Test 1, which was a dioxin/furan test. This was the first test on the commercial/residential mix. Due to a lack of operating experience on this fuel, maximum unit load could not be achieved. Average load was only 5.7 MW, and CO concentrations were higher than normal due to the cooler furnace temperatures.

An additional unit problem was experienced during Test 18, which was a metals test while burning commercial refuse. Following the test, visible quantities of particulate were observed on the filters of both the ESA and

CARB stack metals test samples. Since visible particulates are not normally seen in stack samples collected at Commerce, a baghouse inspection was conducted. It was discovered that a bag had loosened and fallen off its support. Thus, the levels of trace metals measured for this test are significantly higher than normal operation.

In order to achieve three metals test runs while firing commercial refuse with the baghouse functioning properly, a fourth metals test was conducted on the commercial fuel at the end of the test program.

TABLE 2-1
SUMMARY OF UNIT OPERATION

Test	Date 1988	Refuse Type*	Load, MW gross	Steam Flow, Klb/hr	Furnace O_2, %	Refuse Charging Rate, tpd
1	7/18	M	5.7	65	10.2	294
2	7/19	M	10.6	104	6.6	491
3	7/19	M	11.2	110	6.1	---
4	7/20	M	10.1	101	6.6	491
5	7/20	M	11.2	110	5.7	---
6	7/21	M	10.9	109	6.4	513
7	7/21	M	11.1	113	5.8	---
8	7/22	M	10.4	107	6.1	505
9	7/22	M	11.3	115	6.0	---
10	7/23	M	10.9	112	6.3	489
11	7/23	M	10.3	107	6.3	---
12	7/25	C	11.3	115	5.8	345
13	7/26	C	11.4	115	6.2	292
14	7/26	C	11.4	117	5.6	---
15	7/27	C	11.2	114	6.0	412
16	7/27	C	11.3	116	6.3	---
17	7/28	C	11.4	116	6.1	422
18	7/28	C	11.5	118	6.2	---
19	7/29	C	11.2	115	6.5	405
20	7/29	C	10.7	110	6.3	---
21	8/1	C	10.9	113	6.2	333
22	8/1	C	11.1	115	5.9	---
23	8/2	C	11.0	114	6.0	346
24	8/2	C	11.4	117	5.6	---
25	8/3	C	11.5	118	6.1	404
26	8/3	C	11.4	118	5.6	---
27	8/4	C	11.0	115	6.9	411
28	8/4	C	11.4	117	6.8	---
29	8/5	C	11.4	118	6.6	418

* M - mixed refuse
  C - commercial refuse

SECTION 3.0

TEST DESCRIPTION

This section presents discussions of the test schedule, sample locations, test procedures, and quality assurance procedures for the program.

The procedures are based on the test protocol entitled "Test Plan for Air Emission Tests during the Waste-to-Energy Demonstration Program at the Commerce Refuse-to-Energy Facility," Report No. ESR 20526-520. This protocol was submitted to the SCAQMD and CARB for review in April 1988.

Following two meetings with SCAQMD and CARB personnel to review the protocol, and number of revisions and clarifications to the test plan were agreed upon. These revisions were documented in a letter from Mark McDannel of ESA to Mohsen Nazemi of the SCAQMD dated July 8, 1988 (reference No. ESL 20534 MDM-006).

3.1 TEST SCHEDULE

The tests were conducted from July 18 through August 5, 1988. The test schedule is presented in Table 3-1.

Tests 1 through 11 were conducted on the residential/commercial mix from July 18 through 23, and Tests 12 through 29 were conducted on commercial refuse from July 25 through August 5.

As nearly as practical, all tests consisted of four sample trains run simultaneously: ESA's stack sample, ESA's boiler exit sample, CARB's stack sample, and CARB's boiler exit sample. ESA and CARB stack samples were always simultaneous with each other (within a tolerance of five minutes). Boiler exit samples were not always simultaneous with each other or with the stack due to numerous probe plugging problems, probe breakages, and equipment malfunctions. However, the two test teams always began within 30 minutes of each other.

Each type of test was performed in triplicate for each fuel mix, except that the semi-VOST tests while firing the commercial/residential mix were only performed in duplicate.

TABLE 3-1. TEST SCHEDULE FOR WTEDP EMISSION TESTS AT COMMERCE REFUSE-TO-ENERGY FACILITY (Page 1 of 4)

Test No.	Date, 1988	Start Time	Stop Time	Type of Test	Location	Comments
Tests 1 through 11 on residential/commercial mix						
1-Stack-DF	7/18	1431	1900	Dioxin/Furan	Stack	
1-Inlet-DF	7/18	1432	1910	Dioxin/Furan	Inlet	
2-Stack-M5	7/19	1000	1219	M5	Stack	
2-Inlet-M5	7/19	1003	1214	M5	Inlet	
2-Stack-SO_x	7/19	1010	1210	SO_x	Stack	
2-Inlet SO_x	7/19	1000	1135	SO_x	Inlet	Stopped early-filter plugged
3-Stack-Mtls	7/19	1400	1820	Metals	Stack	
3-Inlet-Mtls	7/19	1545	1735	Metals	Inlet	Broken & plugged probe
4-Stack-DF	7/20	0905	1507	Dioxin/Furan	Stack	
4-Inlet-DF	7/20	0902	1500	Dioxin/Furan	Inlet	
4-Stack-HCx	7/20	1452	1552	Bag HC	Stack	Triplicate bags
4-Inlet-HCx	7/20	1452	1551	Bag HC	Inlet	Triplicate bags
5-Stack-Mtls	7/20 and	1645 2140	2023 2239	Metals	Inlet	Delay for power failure
5-Inlet-Mtls	7/20 and	1650 2140	2021 2235	Metals	Inlet	Delay for power failure
6-Stack-SV	7/21	0855	1340	PAH/PCB	Stack	
6-Stack-SV	7/21	0855	1342	PAH/PCB	Inlet	
7-Stack-M5	7/21	1455	1705	Method 5	Stack	
7-Inlet-M5	7/21	1455	1705	Method 5	Inlet	
7-Stack-SO_x	7/21	1455	1705	SO_x	Stack	
7-Inlet-SO_x	7/21	1609	1709	SO_x	Inlet	
8-Stack-DF	7/22	0915	1330	Dioxin/Furan	Stack	
8-Inlet-DF	7/22	0915	1337	Dioxin/Furan	Inlet	
8-Stack-TCA	7/22	1242	1333	Total HC	Stack	Two samples
9-Stack-Mtls	7/22	1440	1853	Metals	stack	
9-Inlet-Mtls	7/22	1440	1853	Metals	Inlet	
9-Stack-CEM	7/22	1810	1910	Gaseous	Stack	
9-Stack-Nit	7/22	1800	1832	Nitrosamines	Stack	
9-Inlet-Nit	7/22	1800	1834	Nitrosamines	Inlet	

(continued

TABLE 3-1. TEST SCHEDULE FOR WTEDP EMISSION TESTS AT COMMERCE REFUSE-TO-ENERGY FACILITY (Page 2 of 4)

Test No.	Date, 1988	Start Time	Stop Time	Type of Test	Location	Comments
10-Stack-SV	7/23	0815	1229	PAH/PCB	Stack	
10-Inlet-SV	7/23	0815	1240	PAH/PCB	Inlet	
10A-Stack-CEM	7/23	0805	0835	Gaseous	Stack	Stopped for plugged line
	and	0920	0950			
10B-Stack-CEM	7/23	1005	1105	Gaseous	Stack	
10A-Stack-Nit	7/23	1029	1049	Nitrosamines	Stack	
10A-Inlet-Nit	7/23	1020	1040	Nitrosamines	Inlet	
10B-Stack-Nit	7/23	1101	1121	Nitrosamines	Stack	
10B-Inlet-Nit	7/23	1101	1121	Nitrosamines	Inlet	
11-Stack-M5	7/23	1410	1623	Method 5	Stack	
11-Inlet-M5	7/23	1432	1623	Method 5	Inlet	
11-Stack-SO_x	7/23	1410	1623	SO_x	Stack	
11-Stack-SO_x	7/23	1523	1623	SO_x	Inlet	
Tests 12 through 29 on commercial refuse						
12-Stack-SV	7/25	1420	1837	PAH/PCB	Stack	
12-Inlet-SV	7/25	1420	1837	PAH/PCB	Inlet	
12A-Stack-Nit	7/25	1433	1503	Nitrosamines	Stack	
12A-Inlet-Nit	7/25	1434	1504	Nitrosamines	Inlet	
12B-Stack-Nit	7/25	1515	1545	Nitrosamines	Stack	
12B-Inlet-Nit	7/25	1515	1545	Nitrosamines	Inlet	
12C-Stack-Nit	7/25	1611	1641	Nitrosamines	Stack	
12C-Inlet-Nit	7/25	1611	1641	Nitrosamines	Inlet	
13-Stack-Mtls	7/26	1200	1623	Metals	Stack	
13-Inlet-Mtls	7/26	1200	1553	Metals	Inlet	Stopped early-probe plugged
14-Stack-M5	7/26	1720	1928	Method 5	Stack	
14-Inlet-M5	7/26	1720	1928	Method 5	Inlet	
14-Stack-SO_x	7/26	1720	1928	SO_x	Stack	
14-Inlet-SO_x	7/26	1720	1843	SO_x	Inlet	Stopped early-filter plugged
15-Stack-DF	7/27	0835	1249	Dioxin/Furan	Stack	
15-Inlet-DF	7/27	0906	1258	Dioxin/Furan	Inlet	
16-Stack-Mtls	7/27	1435	1855	Metals	Stack	
16-Inlet-Mtls	7/27	1455	1855	Metals	Inlet	
16-Stack-TCA	7/27	1600	1630	Total HC	Stack	

(Continued)

TABLE 3-1. TEST SCHEDULE FOR WTEDP EMISSION TESTS AT COMMERCE REFUSE-TO-ENERGY FACILITY (Page 3 of 4)

Test No.	Date, 1988	Start Time	Stop Time	Type of Test	Location	Comments
17-Stack-DF	7/28	0835	1248	Dioxin/Furan	Stack	
17-Inlet-DF	7/28	0835	1248	Dioxin/Furan	Inlet	
17-Stack-HCx	7/28	0945	1032	Bag HC	Stack	Triplicate bags
17-Inlet-HCx	7/28	0945	1032	Bag HC	Inlet	Triplicate bags
18-Stack-Mtls	7/28	1355	1810	Metals	Stack	Baghouse leak
18-Inlet-Mtls	7/28	1355	1810	Metals	Inlet	
18A-Stack-CEM	7/28	1350	1456	Gaseous	Stack	
18B-Stack-CEM	7/28	1506	1608	Gaseous	Stack	
18C-Stack-CEM	7/28	1622	1714	Gaseous	Stack	
19-Stack-SV	7/29	0855	1310	PAH/PCB	Stack	
19-Inlet-SV	7/29	0855	1310	PAH/PCB	Inlet	
20-Stack-M5	7/29	No test		Method 5	Stack	Sampling problems-
20-Inlet-M5	7/29	1500	1710	Method 5	Inlet	results not reporte
20-Stack-SO_x	7/29	1510	1655	SO_x	Stack	
20-Inlet-SO_x	7/29	1500	1713	SO_x	Inlet	
21-Stack-M5	8/1	0830	1035	Method 5	Stack	Repeat of
21-Inlet-M5	8/1	0830	1035	Method 5	Inlet	Test 20
21-Stack-SO_x	8/1	0830	1035	SO_x	Stack	
21-Inlet-SO_x	8/1	0835	1035	SO_x	Inlet	
22-Stack-DF	8/1	1145	1555	Dioxin/Furan	Stack	
22-Inlet-DF	8/1 and	1145 1357	1245 1537	Dioxin/Furan	Inlet	Broken probe and plugged filter
23-Stack-Cr	8/2	0855	1305	Chromium	Stack	
23-Inlet-Cr	8/2	0855	1305	Chromium	Inlet	
24-Stack-SV	8/2	1400	1810	PAH/PCB	Stack	
24-Inlet-SV	8/2	1405	1820	PAH/PCB	Inlet	
25-Stack-Cr	8/3	0830	1235	Chromium	Stack	
25-Inlet-Cr	8/3	0830	1205	Chromium	Inlet	Stopped early- plugged filter
26-Stack-Cr	8/3	1500	1915	Chromium	Stack	
26-Inlet-Cr	8/3	1500	1915	Chromium	Inlet	

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TABLE 3-1. TEST SCHEDULE FOR WTEDP EMISSION TESTS AT COMMERCE REFUSE-TO-ENERGY FACILITY (Page 4 of 4)

Test No.	Date, 1988	Start Time	Stop Time	Type of Test	Location	Comments
26A-Stk-CH2O	8/3	1500	1550	Formaldehyde	Stack	
26B-Stk-CH2O	8/3	1635	1735	Formaldehyde	Stack	
27-Stack-M5	8/4	0845	1056	Method 5	Stack	
27-Inlet-M5	8/4	0912	1012	Method 5	Inlet	Plugged filter
27-Stack-SO_x	8/4	0845	1055	SO_x	Stack	
27-Inlet-SO_x	8/4	0912	1022	SO_x	Inlet	
28-Stack-DF	8/4	1205	1616	Dioxin/Furan	Stack	Exchange test
28-Stk-CH2O	8/4	1505	1605	Formaldehyde	Stack	
29-Stack-Mtls	8/5	0755	1215	Metals	Stack	Repeat of
29-Inlet-Mtls	8/5	0755	1215	Metals	Inlet	Test 18

3.2 SAMPLE LOCATIONS

Stack samples were collected at sample ports which meet EPA Method 1 requirements of being at least two stack diameters downstream and one-half stack diameter upstream of the nearest flow disturbance.

All isokinetic tests (particulate, metals, chrome, dioxin/furan, and semi-VOST tests) were performed by traversing two stack diameters using points selected accordingly to EPA Method 1.

Gaseous samples at the stack (hydrocarbon, nitrosamine, formaldehyde, SO_x, and CEM) were collected at single points since earlier gaseous testing on this unit showed no stratification of gaseous species.

At the boiler exit, the same sample ports used in 1987 were used. Although these ports are less than two duct diameters downstream of the nearest flow disturbance, three-dimensional velocity testing performed according to EPA Method 1 showed that flow angles are acceptable under Method 1 criteria.

Because of the presence of two test crews at this location, the proximity of the sample ports to each other, and the use of 12- to 14-foot

glass probes, switching ports during a test as was done at the stack presented a high risk of breaking probes or other sample train components. With the tight test schedule, such a breakage would have resulted in complete loss of a boiler exit test or an unacceptable delay in the full test program.

Therefore, all tests at the boiler exit were conducted by traversing a single port per test run. For each set of triplicate sample runs, a different port was used for each run. Thus, a set of triplicate tests included one sample collected in the A port, one in the B port, and one in the C port. In this way a full traverse was conducted over the course of a set of three tests.

3.3 TEST PROCEDURES

The procedures used for these tests are presented in Table 3-2. Included in the table are sample durations, collection and analytical methods, approximate detection limits, and the laboratory that performed the analyses.

Each test series included triplicate runs on each test fuel conducted simultaneously at the boiler exit and stack. In order to obtain the maximum amount of data within the scheduling constraints of the program, sampling consisted of use of the following ten sample trains:

1. PCDD/PCDF: 4-hr samples

2. Semi-VOST: 4-hr samples
   PAH, PCB, chlorobenzenes, chlorophenols

3. Metals: 4-hr samples
   2 impingers with HNO_3 following by one impinger with $KMnO_4$ for Hg collection

4. Particulate/HF/HCl/Be: 2-hr samples
   HCl collected in back-up impingers containing NaOH
   Na and K measured from this sample due to interferences on the metals train

5. Chlorinated volatile hydrocarbons: 15-min integrated bag samples

6. Nitrosamines: 30-minute samples

7. Sulfur oxide: 2-hr samples, simultaneous with particulate tests

TABLE 3-2.
TEST PROCEDURES TO BE USED FOR WTEDP TEST SERIES

Species	Sampling Duration	Collection Method	Analytical Method	Approximate Detection Limit	Laboratory	Sample Train No.
Metals	4 hrs	Method 5 w/glass probe, Teflon-coated filter and nitric acid in impingers (EPA 12, CARB 424)	See Table 3-3	See Table 3-3	See Table 3-4	3
PCDD/PCDF	4 hrs	ASME Semi-VOST	GC/MS	See Table 3-5	Triangle Labs	1
PAH, PCB, Chlorobenzenes Chlorophenols	2 hrs	ASME Semi-VOST*	GC/MS	See Table 3-6	Triangle Labs	2
Chlorobenzene, Chlorophenol, and other Volatile Chlorinated Hydrocarbons	20 min	Tedlar bag	GC/MS	0.1 ppb	CT Labs	5
Total Particulate	2 hrs	EPA 5 with SCAQMD condensible analysis	Gravimetric/ titrimetric	0.001 gr/dscf	ESA	4
HCl	2 hrs	Impingers with NaOH	Mercuric nitrate titration	1 ppm	ESA	4
HF	2 hrs	Impingers with NaOH	Specific ion electrode	1 ppm	ESA	4
Be	2 hrs	EPA	AA	See Table 3-3	See Table 3-4	1-4
Nitrosamines	30 min.	Sample through sorbent cartridge	GC	10-25 ng/m^3	Thermedics	6
Velocity and Moisture	--	EPA 1-4 in conjunction with trains 1-4			ESA	
O_2	--	Portable O_2 in conjunction with trains 1-4 at boiler exit				
SO_x	2 hrs	SCAQMD Method 6.1	Titrimetric	0.5 ppm	ESA	7
Formaldehyde	60 min.	Draft CARB 430	HPLC		Radian	8
Chromium	4 hrs	Wet impingement	CARB 425-colorimetric for Cr^6, AA for Cr	1 ug for Cr^6 0.5 ug for Cr	Colorimetric-ESA AA-Curtis & Tomkins	9
Total Hydrocarbons	30 min.	Evacuated tank w/cold trap, SCAQMD Method 25.1	GC/FID for volatiles, GC/NDIR for condonsibles	0.5 ppm for volatiles, 50 ppm for condensibles	Truesdail	10

*Except for monochlorobenzene and monochlorophenol, which are too volatile to be collected with the semi-VOST method.

NOTE: One blank collected and analyzed for each type of test.

8. Formaldehyde: 20- to 60-minute samples at stack only

9. Chromium: 4-hr samples collected by SCAQMD wet impingement method

10. Total hydrocarbons: 30-minute duplicate samples at stack only

Additionally, continuous gaseous emissions monitoring (NO_x, CO, CO_2, O_2) was provided at the stack. Gaseous data were collected during each sample train run to provide O_2 and CO_2 data for molecular weight and dilution calculations, and to provide NO_x and CO data for informational purposes. Three one-hour compliance runs were performed on each fuel using strict EPA Method 3A, 7E, and 10 procedures.

Continuous SO_2 data was also collected, but the results are not considered valid due to the low SO_2 levels, possible NH_3 interference, and instrument zero drifts which were larger than the measured SO_2 values.

At the boiler exit, O_2 was measured by a calibrated portable O_2 analyzer. CO_2 at the boiler exit was determined by dilution calculation based on the boiler exit O_2, stack O_2, and stack CO_2.

Additional details on gaseous monitoring are included in Section 3.3.7.

CARB and SCAQMD provided continuous gaseous monitoring at the boiler exit and dry scrubber exit, respectively. This data will be utilized in a more detailed report to be prepared by the Sanitation Districts for the Waste-to-Energy Demonstration Program.

To the fullest extent possible, all tests were conducted simultaneously with similar tests performed by CARB.

3.3.1 Metals

The samples used for metal analyses were collected using an EPA Method 5-type sample train. Modifications to the standard train were as follows:

1. Use of a glass probe (and a glass nozzle at the stack) to eliminate possible probe metal contamination of the sample.

2. Use of a Teflon-coated filter (per CARB method 424) to minimize interference of the filter material with collection and analysis.

3. Use of 0.1 N nitric acid rather than water in the impingers to ensure collection of any volatile metals that might pass through the filter.

4. Use of an impinger containing acidified $KMnO_4$ downstream of the nitric acid impingers to collect Hg.

5. Concentration of impinger samples by low temperature (70°C) evaporation and compositing with probe wash and filter extracts prior to analysis in order to reduce test detection limits. This work was performed by ESA in our laboratory.

Since the particulate loading was very low at the baghouse exit, four-hour samples were collected to reduce the detection limits of the analyses. Velocity, moisture, CO_2, and O_2 were measured in conjunction with each test.

Table 3-3 presents the list of metals analyzed, along with the methods of analysis and lower detection limits for each metal. Other specific aspects relevant to the testing were listed in Table 3-4.

Samples were analyzed by a variety of techniques in order to achieve the required detection limits on all the species of interest. Neutron activation analysis (NAA), performed by North Carolina State University, was used to analyze a broad spectrum of elements and achieve low detection limits.

Other methods were used for metals which cannot be measured by NAA, (bismuth, boron, calcium, lead, phosphorus, potassium, silicon, sodium, and tin), and for metals for which lower detection limits were required (arsenic, beryllium, cadium, chromium, and nickel). These analyses were all performed by Curtis & Tomkins, Ltd., in Los Angeles.

Because of the very low levels expected for these metals, all sampling and sample handling were conducted with a great deal of care to avoid any contamination. Table 3-4 outlines some of the techniques used to ensure sample integrity such as analysis of a reagent/filter blank, use of virgin sample containers cleaned according to EPA methods, and adherence to strict chain of custody procedures.

3.3.2 Hydrocarbons

Trace hydrocarbons specified for these tests include polychlorinated dibenzodioxins and furans (PCDD/PCDF), polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), chlorophenols, chlorobenzenes, and volatile chlorinated hydrocarbons.

All of the species were collected by the CARB Semi-VOST method (Modified Method 5), with the exception of monochlorophenol and monochlorobenzene, and other chlorinated hydrocarbons which are too volatile to be collected in the Semi-VOST train. All species were analyzed by GC/MS. Discussions of the two separate methods are presented below.

TABLE 3-3. METALS ANALYZED

Metal	Analytical Metal	Quantitation Limit, ug/train	Test Quantitation Limit, ug/m^3*
Aluminum	NAA	75	13
Antimony	NAA	0.25	0.042
Arsenic	Graphite Furnace AA	0.1	0.02
Barium	NAA	410	68
Beryllium**	Graphite Furnace AA	.2	0.07
Bismuth	Graphite Furnace AA	0.1	0.02
Boron	ICP	125	20.8
Cadmium	Graphite Furnace AA	0.1	0.02
Calcium	ICP	5	0.8
Chromium	Graphite Furnace AA	0.2	0.07
Hex Chrome	Colorimetric	1	0.3
Cobalt	NAA	2.5	0.42
Copper	NAA	250	42
Indium	NAA	0.25	0.042
Iron	NAA	250	42
Lead	Graphite Furnace	2.5	0.42
Magnesium	NAA	1,250	208
Manganese	NAA	0.25	0.04
Mercury	NAA	2.5	0.42
Molybolenum	NAA	25	4.2
Nickel	Graphite Furnace AA	0.1	0.02
Phosphorus	Colorimetric	50,000	8,000
Potassium**	AAS	10.0	13.3
Selenium	NAA	10.0	1.67
Silicon	ICP	10	1.7
Sodium**	ICP	10.0	13.3
Tin	ICP	10	1.7
Vanadium	NAA	0.25	0.042
Zinc	NAA	47.5	7.92

* Assume 6 m^3 gas sample, 0.25 liter liquid for analysis. Actual gas and liquid volumes vary from test to test.

** Samples taken from particulate test rather than metals train

TABLE 3-4.
METALS TEST INFORMATION

Sampling Method	EPA 5 with glass probe, Teflon-coated filter, nitric acid impingers.
Analytical Method and Detection Limits	See Table 3-3.
Analytical Laboratory	North Carolina State University (neutron activation analysis) Curtis & Tomkins (other methods)
Sample Volume	6 m^3 to 9 m^3 (4-hr sample)
Sample Compositing	Filter extracted with nitric acid, and composited with probe wash and impingers prior to analysis.
Blank	Filter and reagent blank extracted, composited, and analyzed the same as samples.
Sample Containers	Virgin containers (cleaned according to EPA procedures)
Chain of Custody	Maintained by ESA and outside labs on all samples

Semi-VOST. PCDD/PCDF, PAH, PCB and chlorobenzenes and chlorophenols were collected according to the CARB semi-VOST method. Tetra- through octa-PCDDs and PCDFs were measured including all 2,3,7,8 isomers and mono- through deca-chlorinated PCB cogeners. Table 3-5 summarizes the pertinent information for this test. Detection limits for PAH, PCB, chlorobenzenes, and chlorophenols are shown in Table 3-6. In this procedure a sample is collected isokinetically and passed through a heated Method 5 filter followed by an XAD-2 sorbent module in a water-cooled jacket. The sorbent module is followed by an impinger train to collect moisture and any species of interest that might pass through the resin.

TABLE 3-5.
SEMI-VOST TEST INFORMATION

Sampling Method	ASME Semi-VOST (Modified Method 5)
Analytical Method	GC/MS
Analytical Laboratory	Triangle Labs
Expected Detection Levels	PCDD/PCDF: 0.05 ng/m^3 (per homologue class) PAH, PCB: See Table 3-6
Sample Volumes	6-8 m^3 (4-hr sample)
Surrogate Spiking	Pre- and post test laboratory spikes using appropriate surrogate compounds
Blank	Full field blank train assembled, recovered, and analyzed.
Fractions Analyzed	Probe wash, filter, sorbent module, connecting glassware rinse, and first impinger combined
Chain of Custody	Maintained by ESA and Triangle Labs on all samples
Sample Train Assembly and Recovery	Performed in on-site clean room to minimize chance of contamination
Glassware Cleaning	Thorough cleaning followed by DIH_2O, acetone, and hexane rinses and high temperature bake

TABLE 3-6.
EXPECTED DETECTION LIMITS FOR PAH, PCB, CHLOROBENZENES, AND CHLOROPHENOLS

		ng/sample*	ng/dscm*
PAH			
1.	Benzo-a-anthracene **	10-50	3-13
2.	Benzo-a-pyrene **	10-50	3-13
3.	Benzo-k-fluoranthene **	10-50	3-13
4.	Chrysene **	10-50	3-13
5.	Dibenz-ah-anthracene **	10-50	3-13
6	Indeno (1,2,3-cd) pyrene	100-500	25-125
7	Napthalene	100-500	25-125
8.	Acenapthene	100-500	25-125
9.	Fluorene	100-500	25-125
10.	Phenanthrene	100-500	25-125
11.	Pyrene	100-500	25-125
12.	Benzo[b]fluoranthene	100-500	25-125
13.	Benzo(ghi)perylene	100-500	25-125
14.	Acenapthalene	100-500	25-125
Chlorobenzenes, Chlorophenols (except monochlorobenzenes and monochlorophenol)		100-500	25-125
PCB's **		10-50	3-13

* The lower detection limit represents the target detection limit, and is dependent on the laboratories' ability to concentrate the sample to .1 ml.

** These compounds were analyzed using selected ion monitoring and other sophisticated analytical techniques to achieve lower detection limits than are routinely available.

In order to provide lower detection limits on the PAH and PCB species than were obtained at Commerce in 1987, separate trains were collected for PCDD/PCDF and PAH/PCB analyses. The use of separate trains was necessary to provide the lowest possible detection limit for PAH's and PCB's.

Sample analysis was performed by Triangle Labs in Research Triangle Park, NC. Triangle Labs also prepared the resin, loaded the modules and extracted the modules and other fractions according to ASME or EPA procedures. Surrogates were introduced to the sample resin before and after sampling by Triangle Labs, and the percent recovery is reported in the Appendices. Flow charts of the extraction and analytical procedures used by Triangle are shown in Appendix A.

Chlorobenzene, Chlorophenol, and Other Volatile Hydrocarbons. Chlorobenzene and chlorophenol cannot be measured accurately by the semi-VOST method because they are too volatile to be retained on the XAD resin. Therefore, samples were collected in Tedlar bags.

Ten liters of sample were pulled at a sampling rate of 1 lpm. Two samples at each location plus a blank were collected and analyzed for each test. The bags were sealed and delivered to CTL Labs in South Gate, CA, for analysis within a target time of 24 to 72 hours of collection. The samples were analyzed by GC/MS, with detection limits in the ppb range.

Total Hydrocarbons. Total hydrocarbons were measured by the SCAQMD total carbon analysis (TCA) procedure, in which a sample is collected in an evacuated flask preceded by a supercooled trap. Volatile species collected in the tank were analyzed by TCA/FID, which has a detection limit on the order of 1 ppm. Condensible species collected in the trap were analyzed by TCA/NDIR, which has a lower detection limit of approximately 50 ppm and is subject to significant positive interferences when used on combustion sources.

3.3.3 Particulate, HCl, HF, and Be

Total particulate samples were collected by EPA Method 5. SCAQMD procedures for analysis were followed, including correction for pseudo-particulate formed by reaction of NH_3 and SO_2 in the impingers. In order to account for sulfuric acid mist, sulfur oxide tests were performed according to draft SCAQMD Method 6.1. A sulfur oxide test was performed simultaneously

with each particulate test at the stack and boiler exit. Single point samples were performed at the stack. At the boiler exit, three single point samples at three different sample points were performed for the three test runs.

The probe wash, filter, and impinger samples were analyzed for beryllium according to EPA Method 104. Aliquots of the impinger catches were analyzed for HCl by mercuric nitrate titration and for HF by specific ion electrode (EPA Method 13B). In order to ensure that all of the HCl was collected, an impinger containing 0.1 N NaOH was used downstream of the two water impingers to collect any HCl that might not be collected in water. Aliquots of this impinger were proportionally added to aliquots of impingers 1 and 2 and titrated separately for HCl.

3.3.4 Nitrosamines

In nitrosamine sampling, a measured volume of flue gas is drawn from the stack at a rate of 4.0 liters/min for 30 minutes through a heated quartz probe (200°F) and two Thermo Electron Corp. (TECO) ThermoSorb/N samplers in series containing proprietary sorbent materials. The second cartridge was used as a backup in case of saturation and breakthrough on the first cartridge. After the samples were obtained, the cartridges were returned to the TECO laboratory for analysis. In order to condition the gas sample before it reached the collecting resin, the resin was preceded by an impinger containing a phosphate/citric acid buffer solution recommended by Thermedics, the outside laboratory performing the analyses. Samples were collected on the same day CARB collected nitrosamine samples, but not at the same time. Analyses for nitrosamines were performed on the buffer solution and on the first cartridge from each test. Since detectable levels of nitrosamines were not found on any of the first cartridges, the second cartridges were not analyzed.

The nitrosamines are extracted from the cartridges by a solvent back-flushing technique. The sample is then analyzed by using a gas chromatograph designed for nitrosamine measurement. The nitrosamine compounds in the carrier gas of the gas chromatograph pass through a catalytic heater where N/NO bonds are broken with the release of nitrosyl radicals (NO). The NO concentration is then measured by chemiluminescence and used to determine the nitrosamine content of the sample.

3.3.5 Formaldehyde

Formaldehyde samples were collected according to draft CARB Method 430. Samples were drawn through 2 midget impingers in series, each containing an aqueous acidic solution of 2,4-dinitrophenyl-hydrazine (DNPH). Formaldehyde reacts with DNPH by nucleophilic addition on the carbonyl followed by 1,2-elimination of water and the formation of the 2,4-dinitrophenylhydrazone. Acid is required to promote protonation of the carbonyl because DNPH is a weak nucleophile.

After organic solvent extraction, the DNPH-formaldehyde derivative is determined using reverse phase HPLC with an ultraviolet (UV) adsorption detector operated at 360 nm.

Formaldehyde in the sample is identified and quantified by comparison of retention times and area counts, respectively, with those of standard samples.

3.3.6 Chromium

Total and hexavalent chromium were sampled by a dedicated sample train using the SCAQMD wet impingement procedure with the exception that a sodium hydroxide solution was used in the impingers rather than water. Analyses were according to CARB Method 425. Four-hour samples were collected isokinetically. Total chromium was also measured as part of the full metals tests conducted separately.

3.3.7 Continuous Gaseous Monitoring

ESA performed gaseous monitoring at the stack during all sample train testing. Sampling included three one-hour runs on each fuel mix by EPA Method 3A, 7E, and 10 for O_2, CO_2, NO_x, and CO. Continuous sampling outside of these three runs was performed during all other testing. Instruments were calibrated at regular intervals and system bias calibration checks were performed once per day. Single-point sampling was used for gaseous species. All instrument calibration drift and other CEM performance data were fully documented and are included in Appendix B.3.

CO was measured using a TECO Model 48 analyzer, set on the 0-200 ppm range. For the rare occasions when CO concentrations momentarily exceeded 200 ppm, the instrument's second signal output was set for 0-1000 ppm and connected to a data logger. Thus, the 0-200 ppm range covered all normal operating conditions while the 0-1000 ppm range covered any upset conditions.

For NO_x, repeated checks during this program and earlier programs at Commerce have shown no detectable NO_2 present in the exhaust gases at the stack.

3.4 QUALITY ASSURANCE

ESA has a rigorous ongoing QA program to ensure that high-quality data is obtained and to ensure full documentation of test details. The QA program includes:

1. Appointment of a Quality Assurance officer for ESA's Source Test Division.
2. Preparation of a QA manual for internal use.
3. Standardization of reporting and review procedures.
4. Implementation of chain of custody procedures on all samples and data sheets.
5. Scheduling of internal QA and training meetings.
6. Complete documentation of instrument calibration and CEM performance data.
7. Adherence to method-specific QA procedures for all testing.
8. Personnel training.
9. Monitoring of new and emerging methods and technologies.

Specific QA data which is included in the appendices of this report are:

1. Equipment calibration data
2. CEM calibration
3. CEM performance data
4. Chain of custody on all samples

ESA participates in EPA's audit programs for Method 5, 6, and 7, and is certified by the California Air Resources Board under its Independent Source Tester's Approval program. Additional QA information is presented in Appendix B.

For this program, an additional QA procedure was performed for the PCDD/PCDF tests. On the fourth PCDD/PCDF sample collected while firing commercial refuse, ESA's sample was sent to CARB's contractor (CAL Labs) for analysis and CARB's sample was sent to ESA's contractor (Triangle Labs) for analysis.

SECTION 4.0

RESULTS

This section presents the results of the air emission tests during the WTEDP project at Commerce, along with discussions relevant to how details of sampling and analysis may impact interpretation and use of the results. The results of the criteria pollutant tests are presented in Section 4.1, and the results of the noncriteria pollutant tests are presented in Section 4.2. Data sheets, calculations, laboratory reports, and quality assurance information are included in the Appendices.

4.1 CRITERIA POLLUTANTS

The results of the criteria pollutant tests are summarized in Table 4-1. Emission rates for all species were below SCAQMD prohibitory rules and permit conditions. Detailed results of the tests are presented in the following tables:

Table 4-2. NO_x and CO with residential/commercial mix
Table 4-3. NO_x and CO with commercial refuse
Table 4-4. Gaseous emissions for full test program
Table 4-5. Particulate emissions with residential/commercial mix
Table 4-6. Particulate emissions with commercial refuse
Table 4-7. Sulfur oxide emissions with residential/commercial mix
Table 4-8. Sulfur oxide emissions with commercial refuse
Table 4-9. Total hydrocarbons

All of the test results for the criteria pollutants are considered representative of the emissions from the Commerce facility, with the exception of the condensible hydrocarbon results.

These results, as shown in Table 4-9, indicate condensible hydrocarbon concentrations of approximately 145 ppm. These results are considered invalid for two major reasons:

1. Interference by CO_2 and H_2O is known to cause false positive readings on the condensible hydrocarbon fraction of the TCA test. The interference occurs due to the following mechanism:

   a. During sampling, flue gas moisture condenses into liquid water in the unheated sample line between the stack and the trap.

   b. CO_2 in the stack gas dissolves in the water until equilibrium is reached.

   c. The water/CO_2 solution is frozen in the trap, which is immersed in dry ice.

   d. Prior to sample analysis, the trap is purged to remove all gaseous carbon species. However, the CO_2 present in the frozen water remains in the trap, since the purge is conducted while the trap is still cooled.

   e. When the trap is heated to convert all hydrocarbons to CO_2 for measurement, the CO_2 still frozen in the trap is released and erroneously measured as condensible hydrocarbons.

   This mechanism was documented and described in an EPA-sponsored report entitled "Method 25 Evaluation: Evaluation of Trap Recovery Unit Design", Report No. 82SFS1-3-2. The levels of interference documented in that report are on the order of several hundred ppm.

2. The levels of condensible hydrocarbons reported indicate a high level of products of incomplete combustion. However, all other products of incomplete combustion measured at the stack during the test program (CO, CH_4, volatile hydrocarbons, condensible organic particulate, dioxins, etc.) were extremely low. Hydrocarbon measurements recorded by CARB during the program using CARB Method 1-10 were also very low (<5 ppm).

   This fact, combined with the CO_2/H_2O interferences described above, indicate that the levels of condensible hydrocarbons measured for these tests are artifacts of the test procedure and do not represent actual emissions. For this reason, reported mass emission rates for hydrocarbons are based on the volatile hydrocarbon fraction only.

TABLE 4-1.
SUMMARY OF CRITERIA POLLUTANT EMISSIONS,
COMMERCE REFUSE-TO-ENERGY FACILITY, 1988

Species	Mixed Fuel	Commercial Fuel	SCAQMD Emission Units Limit	SCAQMD Emission Units Rule No.
NOx*: ppm at 3% O_2	144	134	225	476
lb/hr	36.4	35.8	41	permit
SOx: ppm at 3% O_2	1.6	4.9	500	407
lb/hr	0.9	1.7	9	permit
CO*: ppm at 3% O_2	36	26	2,000	407
lb/hr	5.5	4.1	18	permit
HC by TCA/FID**: ppm at 3% O_2	12	9		
lb/hr	1.09	0.84	3	permit
Total Particulate:				
gr/dscf at 12% CO_2	0.0050	0.0066		
gr/dscf at 3% O_2	0.0063	0.0086	0.01	476
lb/hr	1.85	2.53	11	476
			5.5	permit
Solid Particulate, lb/hr	0.52	0.28		

* Data presented are for the compliance runs performed according to strict EPA test procedures. Additional NO_x and CO data for all tests are presented in Table 4-4.

** Results for condensible hydrocarbons are considered invalid due to interferences, so only volatile hydrocarbon values are presented. See Section 4.2.1 for discussion.

TABLE 4-2. NO_x AND CO EMISSIONS ON RESIDENTIAL/COMMERCIAL MIX

Test No.	9	10A	10B	Avg.
Date, 1988	7/22	7/23	7/23	--
Sample Time	1810-1910 and 0920-0950	0805-0835	1005-1105	--
O_2, %	9.9	9.5	9.7	9.7
CO_2, %	9.5	9.4	9.6	9.5
Stack flow, dscfm	54,780	55,670	55,670	55,370
NO_x: ppm	84	106	81	90
ppm at 3% O_2	137	166	129	144
lb/hr	33.5	42.9	32.8	36.4
CO: ppm	23	23	21	22
ppm at 3% O_2	37	36	34	36
lb/hr	5.6	5.7	5.2	5.5

TABLE 4-3. NO_x AND CO EMISSIONS ON COMMERCIAL REFUSE

Test No.	18A	18B	18C	Avg.
Date, 1988	7/28	7/28	7/28	--
Sample Time	1350-1456	1506-1608	1622-1714	--
O_2, %	9.6	9.4	9.2	9.4
CO_2, %	9.9	9.9	10.0	9.9
Stack flow, dscfm	57,060	57,060	57,060	57,060
NO_x: ppm	98	87	74	86
ppm at 3% O_2	155	135	113	134
lb/hr	40.7	36.1	30.7	35.8
CO: ppm	18	15	16	16
ppm at 3% O_2	29	23	24	26
lb/hr	4.6	3.8	4.0	4.1

TABLE 4-4. GASEOUS EMISSION RESULTS FOR FULL TEST PROGRAM

Test	Date	Type of Test	NO_x ppm	CO ppm	O_2 %	CO_2 %	NO_x @ 3% O_2 ppm	CO @ 3% O_2 ppm
		Tests 1 through 11 on residential/commercial mix						
1	7/18	Dioxin	89	41	13.0	6.8	213	115
2	7/19	Method 5	90	22	10.2	9.1	151	37
3	7/19	Metals	67	22	9.5	10.1	105	35
4	7/20	Dioxin	80	26	9.6	9.3	126	41
5	7/20	Metals	74	19	9.5	10.1	114	30
6	7/21	PAH/PCB	136	23	9.7	9.2	217	34
7	7/21	Method 5	81	19	9.3	10.1	126	30
8	7/22	Dioxin	85	23	9.7	9.3	138	37
9	7/22	Metals	73	22	9.6	9.9	116	35
10	7/23	PAH/PCB	91	22	9.7	9.5	145	35
11	7/23	Method 5	96	18	9.6	9.3	151	28
		Tests 12 through 29 on commercial refuse						
12	7/25	PAH/PCB	76	48	8.6	10.1	111	70
13	7/26	Metals	83	25	8.8	10.0	123	38
14	7/26	Method 5	82	16	9.0	10.6	124	24
15	7/27	Dioxin	94	21	9.3	10.2	144	33
16	7/27	Metals	88	22	8.2	10.2	124	31
17	7/28	Dioxin	95	16	9.6	9.8	151	25
18	7/28	Metals	86	15	9.2	10.1	132	24
19	7/29	PAH/PCB	80	20	9.9	9.6	130	33
20	7/29	Method 5	82	29	9.6	10.0	132	46
21	8/1	Method 5	65	17	9.6	9.9	103	26
22	8/1	Dioxin	93	18	9.2	10.1	141	28
23	8/2	Chrome	86	40	9.9	9.8	134	61
24	8/2	PAH/PCB	106	14	9.1	10.0	160	21
25	8/3	Chrome	94	14	9.3	9.9	144	22
26	8/3	Chrome	92	27	9.2	10.1	141	41
27	8/4	Method 5	77	18	10.2	9.3	127	32
28	8/4	Dioxin	81	18	9.8	9.6	130	29
29	8/5	Metals	98	15	9.5	9.8	153	24

TABLE 4-5. PARTICULATE EMISSIONS WHILE FIRING RESIDENTIAL/COMMERCIAL MIX

Test No.	2	7	11	Avg.
Stack:				
O_2, %	10.2	9.3	9.6	9.7
CO_2, %	9.1	10.1	9.3	9.5
H_2O, %	18.4	21.1	20.1	19.9
Stack Temp., °F	280	278	287	282
Gas Flow: wacfm	103,800	91,500	99,700	98,300
dscfm	59,300	50,700	55,100	55,000
Total Particulate:				
gr/dscf	.0051	.0052	.0015	.0039
gr/dscf at 12% CO_2	.0068	.0062	.0019	.0050
gr/dscf at 3% O_2	.0085	.0080	.0024	.0063
lb/hr	2.59	2.26	0.71	1.85
Solid Particulate, lb/hr	0.38	0.60	0.59	0.52
Boiler exit:				
O_2, %	8.7	8.2	8.3	8.4
CO_2, %	10.3	11.1	10.4	10.6
H_2O, %	17.6	15.5	17.7	16.9
Gas Temp., °F	537	549	548	545
Gas flow: wacfm	119,600	112,100	121,700	117,800
dscfm	51,000	48,400	51,100	50,200
Total particulate:				
gr/dscf	2.46	1.72	1.31	1.83
gr/dscf at 12% CO_2	2.87	1.86	1.52	2.08
gr/dscf at 3% O_2	3.61	2.43	1.86	2.63
lb/hr	1,078	712	575	788
Solid particulate, lb/hr	1,078	640	560	759
Removal efficiency for total particulate, %	99.76	99.68	99.88	99.77

99.8 %

TABLE 4-6. PARTICULATE EMISSIONS WHILE FIRING COMMERCIAL REFUSE

Test No.	14	21	27	Avg.
Stack:				
O_2, %	9.0	9.6	10.4	9.7
CO_2, %	10.6	9.9	9.1	9.9
H_2O, %	20.2	17.8	20.8	19.6
Stack Temp., °F	280	272	275	276
Gas Flow: wacfm	96,800	91,500	100,400	96,200
dscfm	54,000	53,200	56,000	54,400
			3600 LB/HR × 6 = 21600 LB/HR	
Total Particulate:				
gr/dscf	.0071	.0042	.0050	.0054
gr/dscf at 12% CO_2	.0081	.0051	.0066	.0066
gr/dscf at 3% O_2	.0106	.0067	.0086	.0086
lb/hr	3.30	1.91	2.39	2.53
Solid Particulate, lb/hr	0.17	0.37	0.29	0.28
Boiler exit:				
O_2, %	8.4	7.8	7.2	7.8
CO_2, %	11.1	11.4	11.9	11.5
H_2O, %	16.1	13.3	14.7	14.7
Gas Temp., °F	569	519	553	547
Gas flow: wacfm	122,100	102,600	106,600	110,400
dscfm	51,200	46,800	46,200	48,100
Total particulate:				
gr/dscf	2.03	0.63	0.90	1.19
gr/dscf at 12% CO_2	2.20	0.67	0.91	1.26
gr/dscf at 3% O_2	2.91	0.87	1.18	1.65
lb/hr	890	254	357	500
Solid particulate, lb/hr	873	245	342	487
Removal efficiency for total particulate, %	99.63	99.25	99.33	99.49

99.4%

TABLE 4-7. SULFUR OXIDE MEASUREMENTS WHILE FIRING RESIDENTIAL/COMMERCIAL MIX

Test No.	2	7	11	Avg.
Stack:				
SO_2, ppm	0.83	0.52	3.04	1.46
SO_2, ppm at 3% O_2	1.38	0.80	4.78	2.32
H_2SO_4, ppm	0.03	0.20	0.09	.11
H_2SO_4, ppm at 3% O_2	0.04	0.31	0.14	.16
SO_x, ppm	0.86	0.72	3.13	1.57
SO_x, ppm at 3% O_2	1.42	1.11	4.92	2.48
SO_x, lb/hr as SO_2	0.52	0.37	1.75	0.88
Boiler exit:				
SO_2, ppm	74	74	110	86
SO_2, ppm at 3% O_2	107	105	156	123
H_2SO_4, ppm	20	16	8	15
H_2SO_4, ppm at 3% O_2	28	22	11	20
SO_x, ppm	94	90	118	101
SO_x, ppm at 3% O_2	135	127	167	143
SO_x, lb/hr as SO_2	48.5	44.1	61.0	51.2
Spray dryer/baghouse removal efficiency for SO_x, %	98.9	99.2	97.1	98.3

TABLE 4-8. SULFUR OXIDE MEASUREMENTS WHILE FIRING COMMERCIAL REFUSE

Test No.	14	21	27	Avg.
Stack:				
SO_2, ppm	.60	2.09	6.15	2.95
SO_2, ppm at 3% O_2	.90	3.31	10.25	4.82
H_2SO_4, ppm	.07	.03	.01	.04
H_2SO_4, ppm at 3% O_2	.10	.05	.02	.06
SO_x, ppm	.67	2.12	6.16	2.98
SO_x, ppm at 3% O_2	1.00	3.36	10.27	4.88
SO_x, lb/hr as SO_2	0.37	1.14	3.49	1.67
Boiler exit:				
SO_2, ppm	123	100	109	111
SO_2, ppm at 3% O_2	176	137	143	152
H_2SO_4, ppm	22	7	9	13
H_2SO_4, ppm at 3% O_2	31	10	12	18
SO_x, ppm	145	107	118	123
SO_x, ppm at 3% O_2	207	147	155	170
SO_x, lb/hr as SO_2	75.2	50.7	55.3	60.4
Spray dryer/baghouse removal efficiency for SO_x, %	99.5	97.8	93.7	97.2

TABLE 4-9. HYDROCARBON EMISSIONS AT STACK

Fuel	Residential/Commercial	Commercial
Test No.	8	16
CO, ppm	39	28
CO_2, %	9.9	9.2
CH_4, ppm	<1	1
NMHC:		
Volatile, ppm as C_1	8	6
Condensible, ppm as C_1*	141	149
Volatile, ppm at 3% O_2	12	9
Volatile, lb/hr as CH_4	1.09	0.84

* Condensible hydrocarbon results are considered invalid. See text for discussion.

4.2 NONCRITERIA POLLUTANTS

This section presents the results of the noncriteria pollutant tests. The results are summarized in Table 4-10. Detailed results are presented in the following subsections:

- 4.2.1 Dioxins/Furans
- 4.2.2 Semi-volatile organics
- 4.2.3 Trace metals
- 4.2.4 Volatile organics
- 4.2.5 Formaldehyde
- 4.2.6 Nitrosamines
- 4.2.7 Acid Gases

The subsections also include discussions of several analysis-related issues that have significant impact on presentation and interpretation of the results. The following symbols are used in the results tables presented in this section:

- ND not detected. This indicates that detectable levels were not found for the species of interest.
- E estimated. This term is used for certain dioxin/furan isomers for which levels were above the detection limit but below the quantitation limit, which is the level at which results can be precisely quantified.
- < less than. For organic species, this symbol is used when the values used to determine a calculated result (either an average of several tests or a summation of several individual compounds such as total PCB, total PAH, etc.) include at least one value above the detection level and at least one value below the detection level. For metals, the less than symbol is used for all elements measured at levels below the quantitation limit. The quantitation limit is generally higher than the detection limit for an analytical procedure. Quantitation limits are a function of such factors as detection limits, interferences, and blank values. For many of the metals, quantitation levels were significantly higher than the detection levels presented in the test plan.
- N/A not available. This is used in results tables when a result is not available either because a test was not run or because an analytical result could not be obtained.

TABLE 4-10. SUMMARY OF NON-CRITERIA POLLUTANT EMISSIONS, COMMERCE REFUSE-TO-ENERGY FACILITY, 1988

	Mixed Fuel	Commercial Fuel
Total PCDD/PCDF: ng/Nm^3 at 12% CO_2	1.94[1] 10.72[2]	3.26
PCDD/PCDF Toxic Equivalent by CA DOHS: ng/Nm^3 at 12% CO_2	0.17[1] 0.36[2]	0.22
Total PAH, ug/Nm^3 at 12% CO_2:		
excluding naphthalene[3]	<0.15	<.095
including naphthalene	<0.47	<1.3
Total PCB, ug/Nm^3 at 12% CO_2:	ND<0.385	<0.093
Chlorobenzenes and chlorophenols: ug/Nm^3 at 12% CO_2	ND <1.8	<2.8
Total Chlorinated HC, ppb	<1.2	<1.0
Metals, ug/Nm^3 at 12% CO_2:		
Arsenic	<0.16	<0.08
Beryllium	<0.19	<0.17
Cadmium	2.0	0.4
Chromium	2.4	<0.3
Lead	2.0	3.2
Mercury	41	76
Nickel	6.3	<0.28
Formaldehyde, ppm at 3% O_2	---	0.12
Nitrosamines, ug/Nm^3 at 12% CO_2	ND<8.1	ND<3.9
HCl, ppm at 3% O_2	9.4	7.0
HF, ppm at 3% O_2	0.074	0.087

NOTES:

1. Excluding Test 1, which was conducted at reduced load and during combustion upset conditions
2. Including Test 1
3. Measured naphthalene levels were high for test samples and blanks due to interferences

4.2.1 Dioxins/Furans

The results of the dioxins/furan tests are presented in the following tables:

Table 4-11	Summary of dioxin/furan emissions
Table 4-12	Dioxin/furan emissions at stack while firing commercial/residential mix
Table 4-13	Dioxin/furan emissions at boiler exit while firing commercial/residential mix
Table 4-14	Dioxin/furan emissions at stack while firing commercial/refuse
Table 4-15	Dioxin/furan emissions at boiler exit while firing commercial refuse
Table 4-16	Average toxic equivalent emissions at stack by CA DOHS Method IV

Detailed results for each test are included in Appendix C.3

The results show that total dioxin/furan emissions at the stack (corrected to 12% CO_2) at nominal full load operation were on average 1.9 ng/Nm^3 while firing mixed fuel and on average 3.3 ng/Nm^3 while firing commercial refuse. At the boiler exit, total PCDD/PCDF levels averaged 739 ng/Nm^3 on mixed fuel and averaged 834 ng/Nm^3 on commercial refuse.

There are several factors relating to the results that have implications on their interpretation. These are discussed below.

Stack Emissions for Test 1. Stack dioxin/furan emissions for Test 1 were 28.3 ng/Nm^3, compared to 1.2 to 4.0 ng/Nm^3 for all of the other five stack samples. As was discussed in Section 2.0, unit operation during Test 1 was not normal, due primarily to the fact that boiler operators did not have experience in burning the low Btu residential/commercial mix. As a result, stable combustion conditions were not achieved during the test. Unit load was only 5.7 MW and the average CO level during the test was 115 ppm at 3% O_2 compared to a normal CO range of 20 to 70 ppm. The high CO levels are generally considered an indicator of less than optimum combustion conditions.

Laboratory interferences on boiler exit samples. On four of the six boiler exit samples (Tests 1, 4, 8, and 22), there were significant abnormalities in the analysis, due primarily to interfering compounds. The interferences are caused by other components in the sample which elute from the GC column at the same time as the dioxin/furan species of interest. Since the target detection levels are so low, these interfering species made it difficult to accurately and precisely quantify levels of the species of interest. The interferences will tend to result in high detection levels, a wide scatter of data, and/or erroneously high measurements.

For Test 4, the interferences were considered to be so significant that the analytical laboratory (Triangle) considers the results of Test 4 invalid. Therefore, the results of Test 4 are not included in the results summarized in Table 4-11.

TABLE 4-11. SUMMARY OF DIOXIN/FURAN EMISSION RESULTS

	Total PCDD/PCDF Emissions	
	ng/Nm^3 at 12% CO_2	lb/hr
Stack		
Mixed fuel, full load	1.94	3.04×10^{-7}
Mixed fuel, all tests *	10.72	1.23×10^{-6}
Commercial refuse	3.26	5.23×10^{-7}
Boiler Exit		
Mixed fuel, full load **	739	1.31×10^{-4}
Mixed fuel, all tests **	498	7.88 x 10-5
Commercial refuse	834	1.39×10^{-4}

* Includes Test 1, which was conducted at 50% load under combustion upset conditions.

** Except Test 4, which had invalid laboratory results due to high levels of interference.

TABLE 4-12. PCDD/PCDF EMISSIONS AT STACK WHILE FIRING COMMERCIAL/RESIDENTIAL MIX.

TEST NO DATE, 1988	1-STK-DF JULY 18 ng/Nm3 @ 12% CO2	4-STK-DF JULY 20 ng/Nm3 @ 12% CO2	8-STK-DF JULY 22 ng/Nm3 @ 12% CO2	AVERAGE EXCLUDING TEST 1 ng/Nm3 @ 12% CO2	 lb/hr	AVERAGE INCLUDING TEST 1 ng/Nm3 @ 12% CO2	 lb/hr
2378 TCDD	ND< 0.024	ND< 0.014	ND< 0.007	ND< 0.011	ND<1.61E-09	ND< 0.015	ND<1.94E-09
12378 PCDD	0.023	ND< 0.003	ND< 0.014	ND< 0.009	ND<1.35E-09	< 0.013	<1.75E-09
123478 HxCDD	ND< 0.012	ND< 0.011	ND< 0.004	ND< 0.008	ND<1.18E-09	ND< 0.009	ND<1.23E-09
123678 HxCDD	ND< 0.012	ND< 0.010	ND< 0.004	ND< 0.007	ND<1.12E-09	ND< 0.009	ND<1.19E-09
123789 HxCDD	ND< 0.015	ND< 0.004	ND< 0.005	ND< 0.005	ND<6.93E-10	ND< 0.008	ND<9.95E-10
1234678 HpCDD	ND< 0.043	ND< 0.062	ND< 0.012	ND< 0.037	ND<5.79E-09	ND< 0.039	ND<5.44E-09
OCDD	ND< 0.304	ND< 0.343	ND< 0.037	< 0.190	<2.99E-08	< 0.228	<3.10E-08
2378 TCDF	0.254	ND< 0.057	ND< 0.033	< 0.045	<7.01E-09	< 0.115	<1.39E-08
12378 PCDF	ND< 0.097	0.034	0.024	0.029	4.49E-09	< 0.052	<6.50E-09
23478 PCDF	0.331	ND< 0.109	ND< 0.033	< 0.071	<1.11E-08	< 0.158	<1.95E-08
123478 HxCDF	0.058	ND< 0.062	ND< 0.003	< 0.033	<5.10E-09	< 0.041	<5.52E-09
123678 HxCDF	ND< 0.123	ND< 0.022	ND< 0.010	ND< 0.016	ND<2.46E-09	ND< 0.052	ND<6.14E-09
234678 HxCDF	ND< 0.011	ND< 0.027	ND< 0.007	ND< 0.017	ND<2.73E-09	ND< 0.015	ND<2.21E-09
123789 HxCDF	ND< 0.016	ND< 0.005	ND< 0.005	ND< 0.005	ND<7.28E-10	ND< 0.009	ND<1.06E-09
1234678 HpCDF	ND< 0.289	ND< 0.052	ND< 0.007	< 0.030	<4.62E-09	< 0.116	<1.36E-08
1234789 HpCDF	ND< 0.033	ND< 0.004	ND< 0.009	ND< 0.007	ND<9.96E-10	ND< 0.015	ND<1.85E-09
OCDF	ND< 0.202	ND< 0.007	ND< 0.025	ND< 0.016	ND<2.50E-09	ND< 0.078	ND<9.03E-09
TOTAL TCDD	5.612	0.071	0.063	0.067	1.05E-08	1.915	2.11E-07
TOTAL PCDD	2.071	0.155	0.142	0.149	2.32E-08	0.789	9.08E-08
TOTAL HxCDD	0.066	0.160	0.026	0.093	1.47E-08	0.084	1.22E-08
TOTAL HpCDD	ND< 0.043	ND< 0.069	ND< 0.040	< 0.055	<8.56E-09	< 0.051	<7.29E-09
TOTAL TCDF	15.943	1.245	0.666	0.956	1.50E-07	5.951	6.80E-07
TOTAL PCDF	3.414	0.459	0.163	0.311	4.87E-08	1.345	1.57E-07
TOTAL HxCDF	0.235	0.105	0.040	0.073	1.14E-08	0.127	1.61E-08
TOTAL HpCDF	ND< 0.381	ND< 0.060	ND< 0.007	< 0.034	<5.31E-09	< 0.149	<1.74E-08
	.75	.22	.11				
TOTAL PCDD/PCDF	< 28.271	< 2.676	< 1.211	< 1.944	<3.04E-07	< 10.719	<1.23E-06

Note: Unit load was reduced and CO levels were high for Test 1 due to unstable combustion conditions. See text for discussion.

TABLE 4-13. PCDD/PCDF EMISSIONS AT BOILER EXIT WHILE FIRING COMMERCIAL/RESIDENTIAL MIX.

TEST NO DATE, 1988		1-IN-DF JULY 18 ng/Nm3 @ 12% CO2		4-IN-DF JULY 20 ng/Nm3 @ 12% CO2		8-IN-DF JULY 22 ng/Nm3 @ 12% CO2		AVERAGE EXCLUDING TEST 1 ng/Nm3 @ 12% CO2	lb/hr	AVERAGE EXCLUDING TEST 4 ng/Nm3 @ 12% CO2	lb/hr
2378 TCDD		0.46		2.61		1.16		1.89	2.65E-07	0.81	1.27E-07
12378 PCDD	ND<	1.10		16.43		4.31		10.37	<1.40E-06	2.71	4.39E-07
123478 HxCDD		1.64		12.95		2.57		7.76	1.03E-06	2.10	3.12E-07
123678 HxCDD	ND<	1.72		18.10		4.58		11.34	1.53E-06	< 3.15	<4.95E-07
123789 HxCDD		3.61		42.63		13.49		28.06	3.85E-06	8.55	1.38E-06
1234678 HpCDD		11.03		70.56		13.53		42.04	5.59E-06	12.28	1.77E-06
OCDD		19.76	ND<	171.53		12.43	<	91.98	<1.17E-05	16.09	2.12E-06
2378 TCDF		3.29		13.31		13.78		13.55	2.05E-06	8.54	1.39E-06
12378 PCDF		3.08		69.64		4.46		37.05	4.72E-06	3.77	5.54E-07
23478 PCDF		7.65		76.74		15.04		45.89	6.10E-06	11.35	1.73E-06
123478 HxCDF		9.22		508.58		28.75		268.66	3.42E-05	18.98	3.03E-06
123678 HxCDF	ND<	3.58	ND<	22.60		8.10	<	15.35	<2.12E-06	< 5.84	<9.05E-07
234678 HxCDF		6.80		1607.32		15.49		811.41	1.01E-04	11.14	1.73E-06
123789 HxCDF	ND<	0.34	ND<	40.71		3.39	<	22.05	<2.83E-06	< 1.86	<3.18E-07
1234678 HpCDF		11.59		64.35		18.53		41.44	5.65E-06	15.06	2.25E-06
1234789 HpCDF	ND<	1.64	ND<	70.89		2.06	<	36.48	<4.59E-06	< 1.85	<2.67E-07
OCDF	ND<	5.76		51.70	ND<	3.36	<	27.53	<3.51E-06	ND< 4.56	ND<5.97E-07
TOTAL TCDD		16.74		8.62		91.90		50.26	8.69E-06	54.32	9.02E-06
TOTAL PCDD		12.71		54.66		100.77		77.71	1.24E-05	56.74	9.61E-06
TOTAL HxCDD		25.15		204.90		73.58		139.24	1.93E-05	49.36	7.86E-06
TOTAL HpCDD		25.40		140.00		29.73		84.86	1.13E-05	27.57	3.95E-06
TOTAL TCDF		69.48		77.05		252.62		164.83	2.72E-05	161.05	2.60E-05
TOTAL PCDF		37.63		245.26		70.18		157.72	2.14E-05	53.91	8.15E-06
TOTAL HxCDF		24.39		2584.87		75.94		1330.41	1.68E-04	50.17	8.02E-06
TOTAL HpCDF		19.58		92.20		28.42		60.31	8.27E-06	24.00	3.54E-06
TOTAL PCDD/PCDF	<	256.59	<	3630.77	<	738.95	<	2184.86	<2.91E-04	< 497.77	<7.88E-05

Notes: 1. Test 4-In-DF considered invalid due to interferences. See text for discussion.
2. Significant levels of interferences were also seen on the samples from Tests 1-In-DF and 8-In-DF.

TABLE 4-14. PCDD/PCDF EMISSIONS AT STACK WHILE FIRING COMMERCIAL REFUSE.

TEST NO	15-STK-DF		17-STK-DF		22-STK-DF		AVERAGE	
DATE, 1988	JULY 27		JULY 28		AUG 1			
	ng/Nm3 @ 12% CO2		ng/Nm3 @ 12% CO2		ng/Nm3 @ 12% CO2		ng/Nm3 @ 12% CO2	lb/hr
	********		********		********		********	*****
2378 TCDD	ND<	0.005	ND< 0.010		ND< 0.005		ND< 0.007	ND<1.09E-09
12378 PCDD	ND<	0.030	ND< 0.085		ND< 0.016		ND< 0.044	ND<7.05E-09
123478 HxCDD	ND<	0.022	ND< 0.091		ND< 0.008		ND< 0.040	ND<6.64E-09
123678 HxCDD	ND<	0.037	ND< 0.091		ND< 0.008		ND< 0.045	ND<7.33E-09
123789 HxCDD	ND<	0.043	ND< 0.109		ND< 0.020		ND< 0.057	ND<9.33E-09
1234678 HpCDD		0.217	0.405	ND<	0.083	<	0.235	<3.80E-08
OCDD		0.808	0.756		0.371		0.645	1.03E-07
2378 TCDF		0.035	0.046	ND<	0.029	<	0.037	<5.85E-09
12378 PCDF		0.043	ND< 0.058		0.039	<	0.047	<7.53E-09
23478 PCDF	ND<	0.057	ND< 0.069		0.052	<	0.059	<9.54E-09
123478 HxCDF		0.108	ND< 0.116		0.064	<	0.096	<1.54E-08
123678 HxCDF		0.040	ND< 0.062	ND<	0.034	<	0.045	<7.30E-09
234678 HxCDF		0.060	ND< 0.060		0.036	<	0.052	<8.37E-09
123789 HxCDF	ND<	0.021	ND< 0.108	ND<	0.011	ND<	0.047	ND<7.67E-09
1234678 HpCDF		0.284	ND< 0.400		0.097	<	0.260	<4.20E-08
1234789 HpCDF	ND<	0.027	ND< 0.126	ND<	0.016	ND<	0.056	ND<9.22E-09
OCDF	ND<	0.151	ND< 0.233	ND<	0.092	ND<	0.159	ND<2.56E-08
TOTAL TCDD		0.130	ND< 0.286		0.049	<	0.155	<2.51E-08
TOTAL PCDD	ND<	0.142	0.243		0.102	<	0.162	<2.63E-08
TOTAL HxCDD		0.313	0.109		0.119		0.180	2.85E-08
TOTAL HpCDD		0.446	0.684		0.058		0.396	6.37E-08
TOTAL TCDF		0.960	1.006		0.527		0.831	1.33E-07
TOTAL PCDF		0.314	0.255		0.348		0.306	4.90E-08
TOTAL HxCDF		0.358	0.197		0.148		0.234	3.72E-08
TOTAL HpCDF		0.385	0.080		0.115		0.193	3.04E-08
		.120	.32		.18			
TOTAL PCDD/PCDF	<	4.006	< 3.848	<	1.928	<	3.261	<5.23E-07

TABLE 4-15. PCDD/PCDF EMISSIONS AT BOILER EXIT WHILE FIRING COMMERCIAL REFUSE.

TEST NO DATE, 1988	15-IN-DF JULY 27 ng/Nm3 @ 12% CO2	17-IN-DF JULY 28 ng/Nm3 @ 12% CO2	22-IN-DF AUG 1 ng/Nm3 @ 12% CO2	AVERAGE ng/Nm3 @ 12% CO2	lb/hr
2378 TCDD	1.57	0.95	1.67	1.40	2.32E-07
12378 PCDD	3.25	1.91	4.54	3.23	5.40E-07
123478 HxCDD	2.99	1.75	2.56	2.44	4.05E-07
123678 HxCDD	4.59	2.84	2.97	3.47	5.74E-07
123789 HxCDD	8.59	5.78	7.04	7.14	1.18E-06
1234678 HpCDD	21.80	18.16	20.73	20.23	3.35E-06
OCDD	41.77	33.20	28.43	34.47	5.69E-06
2378 TCDF	11.09	6.56	29.12	15.59	2.62E-06
12378 PCDF	10.29	6.68	13.96	10.31	1.72E-06
23478 PCDF	15.66	10.85	15.50	14.00	2.32E-06
123478 HxCDF	29.33	20.64	218.10	89.36	1.51E-05
123678 HxCDF	14.56	9.32	14.95	12.94	2.15E-06
234678 HxCDF	14.93	13.58	329.00	119.17	2.02E-05
123789 HxCDF	ND< 0.85	ND< 0.81	34.08	< 11.91	<2.02E-06
1234678 HpCDF	38.77	40.57	28.55	35.96	5.92E-06
1234789 HpCDF	3.43	5.98	9.31	6.24	1.03E-06
OCDF	12.31	16.42	14.48	14.40	2.38E-06
TOTAL TCDD	28.03	13.68	12.66	18.12	3.00E-06
TOTAL PCDD	37.15	17.06	22.69	25.63	4.25E-06
TOTAL HxCDD	56.95	34.36	42.59	44.64	7.40E-06
TOTAL HpCDD	47.67	36.01	44.76	42.81	7.09E-06
TOTAL TCDF	270.71	158.14	82.17	170.34	2.81E-05
TOTAL PCDF	163.53	103.18	61.94	109.55	1.80E-05
TOTAL HxCDF	134.51	85.31	709.20	309.67	5.23E-05
TOTAL HpCDF	56.90	71.08	65.65	64.54	1.07E-05
TOTAL PCDD/PCDF	< 849.53	< 568.43	1084.56	< 834.17	<1.39E-04

Note: Significant levels of interference were seen on the sample from Test 22-In-DF. See text for discussion.

TABLE 4-16. AVERAGE PCDD/PCDF TOXIC EQUIVALENT DATA AT STACK BY CALIFORNIA DOHS METHOD.

		MIXED FUEL(*)		COMMERCIAL REFUSE	
Species	Weight Factor	ng/Nm3 @ 12% CO2	Toxic equiv	ng/Nm3 @ 12% CO2	Toxic equiv
*******	******	********	*****	********	*****
2378 TCDD	1.00	0.011	0.011	0.007	0.007
12378 PCDD	1.00	0.009	0.009	0.044	0.044
123478 HxCDD	0.03	0.008	0.000	0.040	0:001
123678 HxCDD	0.03	0.007	0.000	0.045	0.001
123789 HxCDD	0.03	0.005	0.000	0.057	0.002
1234678 HpCDD	0.03	0.037	0.001	0.235	0.007
OCDD	0.00	0.190	0.000	0.645	0.000
2378 TCDF	1.00	0.045	0.045	0.037	0.037
12378 PCDF	1.00	0.029	0.029	0.047	0.047
23478 PCDF	1.00	0.071	0.071	0.059	0.059
123478 HxCDF	0.03	0.033	0.001	0.096	0.003
123678 HxCDF	0.03	0.016	0.000	0.045	0.001
234678 HxCDF	0.03	0.017	0.001	0.052	0.002
123789 HxCDF	0.03	0.005	0.000	0.047	0.001
1234678 HpCDF	0.03	0.030	0.001	0.260	0.008
1234789 HpCDF	0.03	0.007	0.000	0.056	0.002
OCDF	0.00	0.016	0.000	0.159	0.000
Total			0.170		0.222

*Excludes Test 1 due to abnormal unit operation. See text for explanation.

4.2.2 Semi-volatile Organic Species

The results of the semi-volatile organic tests are summarized in Table 4-17. Detailed results are presented in the following tables:

Table 4-18	Summary of PAH results at stack
Table 4-19	PAH results at stack
Table 4-20	Summary of PAH results at boiler exit
Table 4-21	PAH results at boiler exit
Table 4-22	Summary of PCB results at stack
Table 4-23	PCB results at stack
Table 4-24	Summary of PCB results at boiler exit
Table 4-25	PCB results at boiler exit
Table 4-26	Summary of chlorobenzene/chlorophenol results at stack
Table 4-27	Chlorobenzene/chlorophenol results at stack
Table 4-28	Summary of chlorobenzene/chlorophenol results at boiler exit
Table 4-29	Chlorobenzene/chlorophenol results at boiler exit.

Stack emission rates of PAH, PCB, chlorobenzenes, and chlorophenols were all near or below the detection limits of the methods used.

There were two significant factors in the analysis of these samples which impact interpretation of the results. These are discussed below.

Naphthalene levels. Significant levels of naphthalene were measured on all of the test samples and on the field blank sample. These levels are attributed by Triangle to the fact that naphthalene is a decomposition product of XAD-2, and forms during storage and handling of resin modules. According to Triangle, it is not uncommon to see microgram levels of naphthalene in resin blank samples. Since the levels of naphthalene measured in the field blank are on the same order of magnitude as those measured in the test samples, it is most likely that formation of naphthalene occurred in all of the resin modules.

The reported levels of naphthalene represent 68% of the total PAH for the mixed fuel stack tests and 93% of the total PAH for the commercial fuel stack tests. Therefore, total PAH results are reported with and without naphthalene. The results without naphthalene are considered to be more representative of actual plant emissions.

PCB results. PCB levels were below detection limits for all species for all stack tests, except for a single measurable level of 0.004 ug/Nm^3 for Penta PCB on Test 19. Detection levels were 0.001 to 0.056 ug/Nm^3 for all species except diPCB, which had detection levels of 1.2 to 3.4 ug/Nm^3 from the first analytical run.

The high detection levels for diPCB were due to the use of 2,4,6-tribromophenol as a surrogate species for the chlorobenzene/chlorophenol analyses. 2,4,6-tribromophenol has the same GC retention time as diPCB, and thus interfered with detection of diPCB. Because of this interference, the first sample analyses resulted in total PCB detection levels including diPCB being 20 to 40 times higher than detection levels for all the other PCB species combined.

Subsequent to this analysis, the remaining portions of the samples were passed through an alumina column to separate the PCBs from the tribromophenol, and the samples were analyzed again. Significantly lower detection limits were achieved, and those results are reported in the tables.

TABLE 4-17. SUMMARY OF SEMI-VOLATILE ORGANIC SPECIES MEASUREMENTS

Species	Commercial/Residential Mix		Commercial Refuse		
	Boiler Exit	Stack	Boiler Exit	Stack	Field Blank *
PAH:					
ug/Nm^3 at 12% CO_2	<31.4	<0.468	<7.7	<1.306	<0.789
lb/hr	$<4.60 \times 10^{-3}$	$<7.22 \times 10^{-5}$	$<1.22 \times 10^{-3}$	$<2.1 \times 10^{-4}$	$<1.24 \times 10^{-4}$
PAH, except naphthalene:					
ug/Nm^3 at 12% CO_2	<25.5	<0.148	<3.8	<.095	<.207
lb/hr	$<3.73 \times 10^{-3}$	$<2.28 \times 10^{-5}$	$<6.06 \times 10^{-4}$	$<1.53 \times 10^{-5}$	$<3.25 \times 10^{-5}$
PCB:					
ug/Nm^3 at 12% CO_2	ND<43.1	ND<0.385	<2.67	<0.093	ND<0.098
lb/hr	$ND<7.2 \times 10^{-3}$	$ND<2.6 \times 10^{-4}$	$<4.3 \times 10^{-4}$	$<1.3 \times 10^{-4}$	$ND<5.8 \times 10^{-5}$
Chlorobenzenes + Chlorophenols					
ug/Nm^3 at 12% CO_2	ND <8.02	ND <1.82	E <9.68	E <2.75	ND <1.34
lb/hr	ND $<1.23 \times 10^{-3}$	ND $<2.81 \times 10^{-4}$	E $<2.22 \times 10^{-3}$	E $<6.51 \times 10^{-4}$	ND $<2.62 \times 10^{-4}$

* based on average stack sample volumes and flows

TABLE 4-18
POLYCYCLIC AROMATIC HYDROCARBONS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
STACK RESULT SUMMARY
(ug/Nm^3 @ 12% CO_2)

Name	Mixed Fuel Avg	Commercial Fuel Avg	Fld Blank
Naphthalene	0.320	1.211	0.583
Acenapthylene	< 0.040	< 0.002	ND<0.0003
Acenapthene	< 0.010	< 0.005	ND<0.0004
Fluorene	0.019	0.007	0.0103
Phenanthrene	0.043	0.037	0.138
Anthracene	ND <0.003	ND<0.0007	ND<0.0004
Fluoranthene	0.007	0.010	0.024
Pyrene	0.006	0.007	0.013
Benzo(A)Anthracene	E 0.002	< 0.004	0.004
Chrysene	0.005	< 0.006	0.007
Benzo(B)Fluoranthene	E 0.003	E 0.003	E 0.002
Benzo(K)Fluoranthene	E 0.003	E 0.003	E 0.002
Benzo(A)Pyrene	< 0.003	< 0.003	E 0.002
Indeno(1,2,3-CD)Pyrene	< 0.002	E 0.004	E 0.003
Dibenz(A,H)Anthracene	ND<0.003	ND<0.003	ND<0.001
Benzo(G,H,I)Perylene	ND<0.002	ND<0.002	ND<0.0007
TOTAL PAH			
ug/Nm^3 @12% CO_2	< 0.465	< 1.303	< 0.787
lb/hr	< 7.17E -05	< 2.10E -04	<1.24E -04
TOTAL PAH, EXCEPT NAPHTHALENE			
ug/Nm^3 @12% CO_2	< 0.145	< 0.092	< 0.205
lb/hr	< 2.23E -05	< 1.48E -05	< 3.22E -05

TABLE 4-19
POLYCYCLIC AROMATIC HYDROCARBONS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
PAH STACK RESULTS
(ug/Nm^3 @ 12% CO_2)

Name	6-STK	10-STK	12-STK	19-STK	24-STK	Fld Blk
Fuel	Mixed	Mixed	Comm'l	Comm'l	Comm'l	
Naphthalene	0.3838	0.2565	0.3746	1.6222	1.6370	0.582
Acenapthylene	ND<0.0022	0.0782	E 0.0049	E 0.0011	ND<0.0005	ND<0.000
Acenapthene	ND<0.0027	0.0165	0.0074	0.0054	ND<0.0006	ND<0.000
Flourene	0.0220	0.0139	0.0082	0.0047	0.0084	0.001
Phenanthrene	0.0295	0.0554	0.0278	0.0255	0.0566	0.137
Anthracene	ND<0.0020	ND<0.0034	ND<0.0009	ND<0.0006	ND<0.0006	ND<0.000
Fluoranthene	0.0078	0.0062	0.0109	0.0084	0.0103	0.023
Pyrene	0.0062	0.0047	0.0100	0.0052	0.0059	0.012
Benzo(A)Anthracene	E 0.0025	E 0.0015	ND<0.0073	ND<0.0009	0.0027	0.003
Chrysene	0.0046	0.0051	ND<0.0122	ND<0.0011	0.0047	0.007
Benzo(B)Fluoranthene	E 0.0026	E 0.0032	E 0.0032	E 0.0010	0.0051	E 0.001
Benzo(K)Fluoranthene	E 0.0026	E 0.0032	E 0.0032	E 0.0010	0.0051	E 0.001
Benzo(A)Pyrene	0.0043	ND<0.0016	ND<0.0031	ND<0.0015	0.0030	E 0.001
Indeno(1,2,3-CD)Pyrene	0.0019	ND<0.0028	E 0.0044	E 0.0040	E 0.0023	E 0.003
Dibenz(A,H)Anthracene	ND<0.0017	ND<0.0032	ND<0.0028	ND<0.0036	ND<0.0013	ND<0.001
Benzo(G,H,I)Perylene	ND<0.0011	ND<0.0020	ND<0.0017	ND<0.0022	E 0.0018	ND<0.000
Total PAH	< 0.4756	< 0.4549	< 0.4801	< 1.6882	< 1.7416	< 0.779
Total PAH, Excluding Naphthalene	< 0.0917	< 0.1984	< 0.1054	< 0.0659	< 0.1046	< 0.196

TABLE 4-20.
POLYCYCLIC AROMATIC HYDROCARBONS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
BOILER EXIT RESULT SUMMARY
(ug/Nm^3 @ 12% CO_2)

Name	Mixed Fuel Avg	Commercial Fuel Avg	Fld Blank
Naphthalene	5.917	3.877	1.955
Acenapthylene	2.504	< 0.350	ND< 0.001
Acenapthene	1.243	< 0.055	ND< 0.001
Flourene	2.641	0.157	0.035
Phenanthrene	13.000	1.087	0.464
Anthracene	ND < 0.009	ND< 0.002	0.001
Fluoranthene	1.087	1.303	0.080
Pyrene	3.031	0.521	0.042
Benzo(A)Anthracene	< 0.041	< 0.098	0.012
Chrysene	< 0.211	< 0.099	0.025
Benzo(B)Fluoranthene	0.076	< 0.009	E 0.005
Benzo(K)Fluoranthene	0.076	< 0.009	E 0.005
Benzo(A)Pyrene	0.194	< 0.009	E 0.006
Indeno(1,2,3-CD)Pyrenend	< 0.035	0.098	E 0.011
Dibenz(A,H)Anthracene	< 1.309	ND< 0.016	ND< 0.004
Benzo(G,H,I)Perylene	ND< 0.025	ND< 0.010	ND< 0.004
TOTAL PAH			
ug/Nm^3 @12% CO_2	< 31.323	< 7.690	< 2.648
lb/hr	< 4.59E -03	< 1.22E -03	<4.29E-04
TOTAL PAH, EXCEPT NAPHTHALENE			
ug/Nm^3 @12% CO_2	< 25.406	< 3.814	< 0.693
lb/hr	< 3.72E -03	< 6.05E -04	<2.61E-05

TABLE 4-21
POLYCYCLIC AROMATIC HYDROCARBONS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
PAH BOILER EXIT
(ug/Nm^3 @ 12% CO_2)

Fuel	Mix 6-IN	Mix 10-IN	Comm'l 12-IN	Comm'l 19-IN	Comm'l 24-IN	Fld Blk
Naphthalene	2.137	9.696	0.728	4.434	6.468	2.056
Acenapthylene	0.169	4.839	0.022	ND< 0.002	1.027	ND<0.001
Acenapthene	0.220	2.266	0.035	ND< 0.002	0.127	ND<0.002
Flourene	0.208	5.074	0.181	0.122	0.168	0.037
Phenanthrene	0.694	25.306	1.883	0.664	0.714	0.487
Anthracene	ND< 0.013	ND< 0.006	ND< 0.003	ND< 0.002	ND< 0.002	ND<0.001
Fluoranthene	0.397	1.776	3.577	0.181	0.150	0.084
Pyrene	0.291	5.771	1.394	0.089	0.080	0.044
Benzo(A)Anthracene	0.066	ND< 0.015	0.087	ND< 0.002	0.205	0.013
Chrysene	0.398	ND< 0.024	0.012	ND< 0.006	0.277	0.026
Benzo(B)Fluoranthene	0.062	0.091	ND< 0.009	0.013	ND< 0.004	E 0.006
Benzo(K)Fluoranthene	0.062	0.091	ND< 0.009	0.013	ND< 0.004	E 0.006
Benzo(A)Pyrene	0.042	0.346	ND< 0.005	0.020	ND< 0.003	E 0.064
Indeno(1,2,3-CD)Pyrene	ND< 0.020	ND< 0.050	0.228	0.050	E 0.016	E 0.012
Dibenz(A,H)Anthracene	ND< 0.023	2.594	ND< 0.033	ND< 0.008	ND< 0.007	ND<0.004
Benzo(G,H,I)Perylene	ND< 0.014	ND< 0.036	ND< 0.021	ND< 0.005	ND< 0.004	ND<0.026
Total PAH	< 4.755	< 57.890	< 8.218	< 5.599	< 9.254	< 2.863
Total PAH, Excluding Naphthalene	< 2.617	< 48.194	< 7.490	< 1.166	< 2.786	< 0.807

TABLE 4-22
PCB STACK RESULT SUMMARY
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
(ug/Nm^3 @ 12% CO_2)

Name	Mixed Fuel Avg	Commercial Fuel Avg	Fld Blank
2-PCB	ND< 0.001	ND< 0.001	ND< 0.001
Total Mono PCB	ND< 0.023	ND< 0.007	ND< 0.005
23-Di PCB	ND< 0.001	ND< 0.001	ND< 0.001
Total Di PCB	ND< 0.267	ND< 0.042	ND< 0.041
245-Tri PCB	ND< 0.001	ND< 0.001	ND< 0,001
Total Tri PCB	ND< 0.045	ND< 0.019	ND< 0.006
2246-Tetra PCB	ND< 0.002	ND< 0.001	ND< 0.001
Total Tetra PCB	ND< 0.021	ND< 0.001	ND< 0.001
22345-Penta PCB	ND< 0.003	ND< 0.001	ND< 0.001
TOTAL Penta PCB	ND< 0.009	< 0.014	ND< 0.034
224456-Hexa PCB	ND< 0.003	ND< 0.002	ND< 0.002
Total Hexa PCB	ND< 0.002	ND< 0.002	ND< 0.002
2234566HeptaPCB	ND< 0.002	ND< 0.001	ND< 0.001
Total Hepta PCB	ND< 0.002	ND< 0.001	ND< 0.001
2234566-Octa PCB	ND< 0.018	ND< 0.002	ND< 0.002
Total Octa PCB	ND< 0.004	ND< 0.002	ND< 0.002
Nona PCB	ND< 0.002	ND< 0.001	ND< 0.001
Total Nona PCB	ND< 0.003	ND< 0.004	ND< 0.006
DECA PCB	ND< 0.008	ND< 0.002	ND< 0.002
TOTAL PCB			
ug/Nm^3 @12% CO_2	ND< 0.385	< 0.093	ND< 0.098
lb/hr	ND<2.6E-04	< 1.3E-04	ND<5.8E-05

TABLE 4-23
PCB STACK RESULTS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
(ug/Nm^3 @ 12% CO_2)

Name	6-STK	10-STK	12-STK	19-STK	24-STK	FLD BLK
Fuel	Mixed	Mixed	Comm'l	Comm'l	Comm'l	
2-PCB	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.000	ND< 0.001
Total Mono PCB	ND< 0.016	ND< 0.030	ND< 0.001	ND< 0.012	ND< 0.008	ND< 0.005
23-Di PCB	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.000	ND< 0.001
Total Di PCB	ND< 0.011	ND< 0.524	ND< 0.005	ND< 0.079	ND< 0.041	ND< 0.041
245-Tri PCB	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.001
Total Tri PCB	ND< 0.056	ND< 0.034	ND< 0.008	ND< 0.029	ND< 0.020	ND< 0.006
2246-Tetra PCB	ND< 0.002	ND< 0.002	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.001
TOTAL Tetra PCB	ND< 0.002	ND< 0.040	ND< 0.001	ND< 0.001	ND< 0.001	ND< 0.001
22345-Penta PCB	ND< 0.003	ND< 0.003	ND< 0.001	ND< 0.002	ND< 0.001	ND< 0.001
TOTAL Penta PCB	ND< 0.003	ND< 0.015	ND< 0.008	0.004	ND< 0.031	ND< 0.034
224456-Hexa PCB	ND< 0.003	ND< 0.003	ND< 0.002	ND< 0.002	ND< 0.001	ND< 0.002
TOTAL Hexa PCB	ND< 0.003	ND< 0.002	ND< 0.002	ND< 0.002	ND< 0.001	ND< 0.002
2234566HeptaPCB	ND< 0.002	ND< 0.002	ND< 0.001	ND< 0.002	ND< 0.001	ND< 0.001
Total Hepta PCB	ND< 0.002	ND< 0.003	ND< 0.001	ND< 0.002	ND< 0.001	ND< 0.001
2234566-Octa PCB	ND< 0.003	ND< 0.034	ND< 0.002	ND< 0.002	ND< 0.001	ND< 0.002
Total Octa PCB	ND< 0.006	ND< 0.002	ND< 0.002	ND< 0.002	ND< 0.001	ND< 0.002
Nona PCB	ND< 0.002	ND< 0.001	ND< 0.002	ND< 0.002	ND< 0.001	ND< 0.001
Total Nona PCB	ND< 0.002	ND< 0.004	ND< 0.002	ND< 0.003	ND< 0.006	ND< 0.006
DECA PCB	ND< 0.013	ND< 0.004	ND< 0.003	ND< 0.003	ND< 0.001	ND< 0.002
Total PCB	ND< .113	ND< .657	ND< 0.033	< 0.136	ND< 0.111	ND< 0.098

TABLE 4-24
PCB BOILER EXIT RESULT SUMMARY
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
(ug/Nm^3 @ 12% CO_2)

Name	Mixed Fuel Avg	Commercial Fuel Avg	Fld Blank
2-PCB	ND< 0.240	ND< 0.001	ND< 0.002
Total Mono PCB	ND< 2.460	ND< 0.219	ND< 0.017
23-Di PCB	ND< 0.005	ND< 0.001	ND< 0.002
Total Di PCB	ND< 3.231	ND< 0.097	ND< 0.145
245-Tri PCB	ND< 0.006	ND< 0.002	ND< 0.002
TOTAL Tri PCB	ND<25.351	ND< 1.367	ND< 0.019
2246-Tetra PCB	ND< 0.008	ND< 0.003	ND< 0.002
TOTAL Tetra PCB	ND< 3.547	< 0.056	ND< 0.002
22345-Penta PCB	ND< 0.013	ND< 0.003	ND< 0.003
Total Penta PCB	ND< 7.563	ND< 0.470	ND< 0.121
224456-Hexa PCB	ND< 0.021	ND< 0.003	ND< 0.006
Total Hexa PCB	ND< 0.057	ND< 0.047	ND< 0.006
2234566HeptaPCB	ND< 5.863	ND< 0.003	ND< 0.003
Total Hepta PCB	ND< 0.019	ND< 0.009	ND< 0.003
2234566-Octa PCB	ND< 0.423	ND< 0.003	ND< 0.006
TOTAL Octa PCB	ND< 0.257	ND< 0.044	ND< 0.006
Nona PCB	ND< 1.052	ND< 0.210	ND< 0.003
Total Nona PCB	ND< 0.537	ND< 0.358	ND< 0.019
DECA PCB	ND< 0.027	ND< 0.005	ND< 0.006
Total PCB			
ug/Nm^3 @12% CO_2	ND<43.050	< 2.672	ND< 0.347
lb/hr	ND< 7.2E-03	<4.3E-04	ND< 5.4×10^{-5}

TABLE 4-25

PCB BOILER EXIT RESULTS

FROM COMMERCE REFUSE-TO-ENERGY FACILITY

(ug/Nm^3 @ 12% CO_2)

Name	6-IN	10-IN	12-IN	19-IN	24-IN	Fld Blk
Fuel	Mixed	Mixed	Comm'l	Comm'l	Comm'l	
2-PCB	ND< 0.476	ND< 0.003	ND< 0.001	ND< 0.001	ND< 0.002	ND< 0.002
Total Mono PCB	ND< 1.052	ND< 3.869	ND< 0.001	ND< 0.365	ND< 0.291	ND< 0.017
23-Di PCB	ND< 0.004	ND< 0.005	ND< 0.001	ND< 0.001	ND< 0.002	ND< 0.002
Total Di PCB	ND< 5.121	ND< 1.341	ND< 0.133	ND< 0.039	ND< 0.119	ND< 0.145
245-Tri PCB	ND< 0.007	ND< 0.005	ND< 0.002	ND< 0.001	ND< 0.002	ND< 0.002
Total Tri PCB	ND< 8.827	ND<41.875	ND< 1.333	ND< 1.872	ND< 0.896	ND< 0.020
2246-Tetra PCB	ND< 0.009	ND< 0.008	ND< 0.002	ND< 0.002	ND< 0.003	ND< 0.002
TOTAL Tetra PCB	ND< 0.620	ND< 6.473	0.017	ND< 0.056	ND< 0.094	ND< 0.002
22345-Penta PCB	ND< 0.013	ND< 0.012	ND< 0.002	ND< 0.002	ND< 0.003	ND< 0.004
TOTAL Penta PCB	ND< 4.352	ND<10.775	ND< 0.536	ND< 0.518	ND< 0.356	ND< 0.121
224456-Hexa PCB	ND< 0.015	ND< 0.027	ND< 0.002	ND< 0.002	ND< 0.005	ND< 0.006
TOTAL Hexa PCB	ND< 0.097	ND< 0.017	ND< 0.019	ND< 0.101	ND< 0.023	ND< 0.006
2234566HeptaPCB	ND< 0.011	ND<11.715	ND< 0.002	ND< 0.002	ND< 0.003	ND< 0.004
Total Hepta PCB	ND< 0.011	ND< 0.027	ND< 0.023	ND< 0.002	ND< 0.003	ND< 0.004
2234566-Octa PCB	ND< 0.017	ND< 0.830	ND< 0.002	ND< 0.002	ND< 0.005	ND< 0.006
Total Octa PCB	ND< 0.496	ND< 0.019	ND< 0.002	ND< 0.002	ND< 0.127	ND< 0.006
Nona PCB	ND< 0.013	ND< 2.091	ND< 0.002	ND< 0.625	ND< 0.003	ND< 0.004
Total Nona PCB	ND< 1.041	ND< 0.033	ND< 0.517	ND< 0.004	ND< 0.552	ND< 0.020
DECA PCB	ND< 0.021	ND< 0.033	ND< 0.004	ND< 0.004	ND< 0.006	ND< 0.006
Total PCB	ND<21.638	ND<64.462	< 2.585	ND< 2.965	ND< 2.467	ND< 0.347

TABLE 4-26
CHLOROBENZENES AND CHLOROPHENOLS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
STACK RESULT SUMMARY
(ug/Nm^3 @ 12% CO_2)

Name	Mixed Fuel Avg	Commercial Fuel Avg
2-Chlorophenol	ND< 0.03	ND< 0.03
1,3-Dichlorobenzene	ND< 0.03	E< 0.09
1,4-Dichlorobenzene	ND< 0.03	E< 0.08
1,2-Dichlorobenzene	ND< 0.04	E< 0.14
1,3,5-Trichlorobenzene	ND< 0.05	E< 0.07
2,4-Dichlorophenol	ND< 0.04	ND< 0.05
2,5-Dichlorophenol	ND< 0.04	ND< 0.04
2,3-Dichlorophenol	ND< 0.07	ND< 0.07
3-Chlorophenol	ND< 0.01	ND< 0.01
2,6-Dichlorophenol	ND< 0.05	ND< 0.05
4-Chlorophenol	ND< 0.01	ND< 0.01
1,2,4-Trichlorobenzene	ND< 0.05	E< 0.30
1,2,3-Trichlorobenzene	ND< 0.05	E< 0.15
4-Chloro-3-Methylphenol	ND< 0.04	ND< 0.04
1,2,3,5-Tetrachlorobenzene	ND< 0.05	E< 0.13
1,2,4,5-Tetrachlorobenzene	ND< 0.06	E< 0.15
2,3,5-Trichlorophenol	ND< 0.07	ND< 0.07
2,4,6-Trichlorophenol	ND< 0.06	E< 0.16
2,4,5-Trichlorophenol	ND< 0.09	ND< 0.07
2,3,4-Trichlorophenol	ND< 0.09	E< 0.26
1,2,3,4-Tetrachlorobenzene	ND< 0.06	ND< 0.05
2,3,6-Trichlorophenol	ND< 0.09	ND< 0.07
3,5-Dichlorophenol	ND< 0.06	ND< 0.04
3,4-Dichlorophenol	ND< 0.06	ND< 0.05
Pentachlorobenzene	ND< 0.08	ND< 0.06
2,3,5,6-Tetrachlorophenol	ND< 0.14	ND< 0.11
2,3,4,6-Tetrachlorophenol	ND< 0.12	ND< 0.09
Hexachlorbenzene	ND< 0.06	ND< 0.07
Pentachlorophenol	ND< 0.19	ND< 0.21
Total chlorobenzes:		
ug/Nm^3 @ 12% CO_2	ND< 0.56	< 1.29
lb/hr	ND< 0.86E-04	< 3.05E-04
Total chlorophenols:		
ug/Nm^3 @ 12% CO_2	ND< 1.26	< 1.46
lb/hr	ND< 1.95E-04	< 3.46E-04

TABLE 4-27
CHLOROBENZENES AND CHLOROPHENOLS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
STACK RESULTS
(ug/NM^3 @ 12% CO_2)

Name	6-STK	10-STK	12-STK	19-STK	24-STK	Fld Blk
2-Chlorophenol	ND< 0.03	ND< 0.04	ND< 0.04	ND< 0.03	ND< 0.03	ND< 0.03
1,3-Dichlorobenzene	ND< 0.02	ND< 0.03	E 0.07	ND< 0.02	E 0.16	ND< 0.02
1,4-Dichlorobenzene	ND< 0.03	ND< 0.04	E 0.07	ND< 0.03	E 0.13	ND< 0.02
1,2-Dichlorobenzene	ND< 0.03	ND< 0.04	E 0.15	ND< 0.04	E 0.25	ND< 0.03
1,3,5-Trichlorobenzene	ND< 0.05	ND< 0.06	ND< 0.06	ND< 0.06	E 0.10	ND< 0.04
2,4-Dichlorophenol	ND< 0.04	ND< 0.04	ND< 0.06	ND< 0.05	ND< 0.04	ND< 0.04
2,5-Dichlorophenol	ND< 0.04	ND< 0.05	ND< 0.05	ND< 0.04	ND< 0.03	ND< 0.03
2,3-Dichlorophenol	ND< 0.06	ND< 0.07	ND< 0.08	ND< 0.07	ND< 0.05	ND< 0.05
3-Chlorophenol	ND< 0.01	ND< 0.02	ND< 0.02	ND< 0.01	ND< 0.01	ND< 0.01
2,6-Dichlorophenol	ND< 0.04	ND< 0.05	ND< 0.05	ND< 0.05	ND< 0.04	ND< 0.04
4-Chlorophenol	ND< 0.01	ND< 0.02	ND< 0.02	ND< 0.01	ND< 0.01	ND< 0.01
1,2,4-Trichlorobenzene	ND< 0.05	ND< 0.06	E 0.16	E 0.62	E 0.62	ND< 0.04
1,2,3-Trichlorobenzene	ND< 0.04	ND< 0.05	ND< 0.06	ND< 0.05	E 0.33	ND< 0.04
4-Chloro-3-Methylphenol	ND< 0.03	ND< 0.04	ND< 0.05	ND< 0.04	ND< 0.03	ND< 0.03
1,2,3,5-Tetrachlorobenzene	ND< 0.04	ND< 0.05	ND< 0.06	ND< 0.05	E 0.28	ND< 0.04
1,2,4,5-Tetrachlorobenzene	ND< 0.05	ND< 0.06	ND< 0.07	ND< 0.06	E 0.34	ND< 0.05
2,3,5-Trichlorophenol	ND< 0.06	ND< 0.08	ND< 0.08	ND< 0.07	ND< 0.06	ND< 0.06
2,4,6-Trichlorophenol	ND< 0.05	ND< 0.07	ND< 0.06	ND< 0.04	E 0.38	ND< 0.03
2,4,5-Trichlorophenol	ND< 0.07	ND< 0.11	ND< 0.10	ND< 0.06	ND< 0.06	ND< 0.06
2,3,4-Trichlorophenol	ND< 0.07	ND< 0.11	ND< 0.10	ND< 0.06	E 0.62	ND< 0.06
1,2,3,4-Tetrachlorobenzene	ND< 0.05	ND< 0.07	ND< 0.06	ND< 0.04	ND< 0.04	ND< 0.04
2,3,6-Trichlorophenol	ND< 0.07	ND< 0.11	ND< 0.10	ND< 0.06	ND< 0.06	ND< 0.06
3,5-Dichlorophenol	ND< 0.04	ND< 0.07	ND< 0.06	ND< 0.04	ND< 0.04	ND< 0.03
3,4-Dichlorophenol	ND< 0.05	ND< 0.08	ND< 0.07	ND< 0.04	ND< 0.04	ND< 0.04
Pentachlorobenzene	ND< 0.06	ND< 0.10	ND< 0.09	ND< 0.05	ND< 0.05	ND< 0.05
2,3,5,6-Tetrachlorophenol	ND< 0.11	ND< 0.17	ND< 0.15	ND< 0.09	ND< 0.09	ND< 0.08
2,3,4,6-Tetrachlorophenol	ND< 0.10	ND< 0.14	ND< 0.13	ND< 0.08	ND< 0.07	ND< 0.07
Hexachlorbenzene	ND< 0.06	ND< 0.07	ND< 0.07	ND< 0.07	ND< 0.06	ND< 0.05
Pentachlorophenol	ND< 0.17	ND< 0.20	ND< 0.23	ND< 0.23	ND< 0.18	ND< 0.16
Total Chlorobenzenes	ND< 0.47	ND< 0.64	ND< 0.90	E< 0.63	E< 2.35	ND< 0.43
Total Chlorophenols	ND< 1.07	ND< 1.47	< 1.43	< 1.09	< 1.84	ND< 0.91

TABLE 4-28
CHLOROBENZENES AND CHLOROPHENOLS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
BOILER EXIT RESULT SUMMARY
(ug/Nm^3 @ 12% CO_2)

Name	Mixed Fuel Avg	Commercial Fuel Avg
2-Chlorophenol	ND< 0.18	ND< 0.11
1,3-Dichlorobenzene	ND< 0.15	E< 0.21
1,4-Dichlorobenzene	ND< 0.17	E< 0.18
1,2-Dichlorobenzene	ND< 0.21	E< 0.13
1,3,5-Trichlorobenzene	ND< 0.13	E< 0.18
2,4-Dichlorophenol	ND< 0.12	ND< 0.17
2,5-Dichlorophenol	ND< 0.10	ND< 0.14
2,3-Dichlorophenol	ND< 0.16	ND< 0.22
3-Chlorophenol	ND< 0.03	ND< 0.05
2,6-Dichlorophenol	ND< 0.11	ND< 0.15
4-Chlorophenol	ND< 0.03	ND< 0.05
1,2,4-Trichlorobenzene	ND< 0.13	E< 0.18
1,2,3-Trichlorobenzene	ND< 0.12	E< 0.16
4-Chloro-3-Methylphenol	ND< 0.09	ND< 0.13
1,2,3,5-Tetrachlorobenzene	ND< 0.12	E< 0.77
1,2,4,5-Tetrachlorobenzene	ND< 0.14	E< 1.00
2,3,5-Trichlorophenol	ND< 0.17	ND< 0.24
2,4,6-Trichlorophenol	ND< 0.30	E< 0.17
2,4,5-Trichlorophenol	ND< 0.48	ND< 0.28
2,3,4-Trichlorophenol	ND< 0.47	E< 0.28
1,2,3,4-Tetrachlorobenzene	ND< 0.31	ND< 0.18
2,3,6-Trichlorophenol	ND< 0.47	ND< 0.28
3,5-Dichlorophenol	ND< 0.29	ND< 0.17
3,4-Dichlorophenol	ND< 0.33	ND< 0.19
Pentachlorobenzene	ND< 0.42	ND< 0.25
2,3,5,6-Tetrachlorophenol	ND< 0.71	ND< 0.42
2,3,4,6-Tetrachlorophenol	ND< 0.62	ND< 2.67
Hexachlorbenzene	ND< 0.35	ND< 0.18
Pentachlorophenol	ND< 1.10	ND< 0.55
Total chlorobenzes:		
ug/Nm^3 @ 12% CO_2	ND< 2.25	< 3.42
lb/hr	ND< 3.5 E-04	< 7.8 E-04
Total chlorophenols:		
ug/Nm^3 @ 12% CO_2	ND< 5.76	< 6.27
lb/hr	ND< 8.8 E-04	< 1.44 E-03

TABLE 4-29
CHLOROBENZENES AND CHLOROPHENOLS
FROM COMMERCE REFUSE-TO-ENERGY FACILITY
BOILER EXIT RESULTS
(ug/NM^3 @ 12% CO_2)

Test	6-IN	10-IN	12-IN	19-IN	24-IN	Fld Blk
Fuel	Mixed	Mixed	Comm'l	Comm'l	Comm'l	
2-Chlorophenol	ND< 0.09	ND< 0.28	ND< 0.17	ND< 0.10	ND< 0.06	ND< 0.03
1,3-Dichlorobenzene	ND< 0.07	ND< 0.22	E 0.14	ND< 0.08	E 0.41	ND< 0.02
1,4-Dichlorobenzene	ND< 0.08	ND< 0.25	E 0.15	ND< 0.09	E 0.31	ND< 0.02
1,2-Dichlorobenzene	ND< 0.10	ND< 0.32	E 0.19	ND< 0.11	E 0.07	ND< 0.03
1,3,5-Trichlorobenzene	ND< 0.15	ND< 0.12	ND< 0.20	ND< 0.20	E 0.14	ND< 0.04
2,4-Dichlorophenol	ND< 0.14	ND< 0.11	ND< 0.19	ND< 0.19	ND< 0.13	ND< 0.04
2,5-Dichlorophenol	ND< 0.12	ND< 0.09	ND< 0.16	ND< 0.16	ND< 0.11	ND< 0.03
2,3-Dichlorophenol	ND< 0.18	ND< 0.14	ND< 0.24	ND< 0.25	ND< 0.17	ND< 0.05
3-Chlorophenol	ND< 0.04	ND< 0.03	ND< 0.05	ND< 0.05	ND< 0.04	ND< 0.01
2,6-Dichlorophenol	ND< 0.12	ND< 0.10	ND< 0.17	ND< 0.17	ND< 0.12	ND< 0.04
4-Chlorophenol	ND< 0.04	ND< 0.03	ND< 0.05	ND< 0.05	ND< 0.04	ND< 0.01
1,2,4-Trichlorobenzene	ND< 0.15	ND< 0.12	E 0.20	E 0.20	E 0.14	ND< 0.04
1,2,3-Trichlorobenzene	ND< 0.13	ND< 0.10	ND< 0.17	ND< 0.17	E 0.12	ND< 0.04
4-Chloro-3-Methylphenol	ND< 0.10	ND< 0.08	ND< 0.14	ND< 0.14	ND< 0.10	ND< 0.03
1,2,3,5-Tetrachlorobenzene	ND< 0.13	ND< 0.10	ND< 0.49	ND< 1.69	E 0.12	ND< 0.04
1,2,4,5-Tetrachlorobenzene	ND< 0.16	ND< 0.12	ND< 0.92	ND< 1.95	E 0.15	ND< 0.05
2,3,5-Trichlorophenol	ND< 0.19	ND< 0.15	ND< 0.26	ND< 0.26	ND< 0.18	ND< 0.06
2,4,6-Trichlorophenol	ND< 0.28	ND< 0.31	ND< 0.25	ND< 0.16	E 0.11	ND< 0.03
2,4,5-Trichlorophenol	ND< 0.45	ND< 0.51	ND< 0.41	ND< 0.26	ND< 0.18	ND< 0.06
2,3,4-Trichlorophenol	ND< 0.44	ND< 0.50	ND< 0.41	ND< 0.26	E 0.17	ND< 0.06
1,2,3,4-Tetrachlorobenzene	ND< 0.29	ND< 0.33	ND< 0.27	ND< 0.17	ND< 0.11	ND< 0.04
2,3,6-Trichlorophenol	ND< 0.44	ND< 0.50	ND< 0.40	ND< 0.26	ND< 0.17	ND< 0.06
3,5-Dichlorophenol	ND< 0.27	ND< 0.31	ND< 0.25	ND< 0.16	ND< 0.11	ND< 0.03
3,4-Dichlorophenol	ND< 0.31	ND< 0.35	ND< 0.28	ND< 0.18	ND< 0.12	ND< 0.04
Pentachlorobenzene	ND< 0.39	ND< 0.44	ND< 0.36	ND< 0.23	ND< 0.15	ND< 0.05
2,3,5,6-Tetrachlorophenol	ND< 0.66	ND< 0.75	ND< 0.61	ND< 0.38	ND< 0.26	ND< 0.08
2,3,4,6-Tetrachlorophenol	ND< 0.58	ND < 0.65	ND< 0.53	ND< 3.55	ND< 3.95	ND< 0.07
Hexachlorbenzene	ND< 0.45	ND< 0.26	ND< 0.24	ND< 0.17	ND< 0.12	ND< 0.05
Pentachlorophenol	ND< 1.39	ND< 0.80	ND< 0.75	ND< 0.53	ND< 0.38	ND< 0.16
Total Chlorobenzenes	ND< 2.08	ND< 2.39	E< 3.33	E< 5.06	E< 1.85	ND< 0.43
Total Chlorophenols	ND< 5.84	ND< 5.72	E< 5.32	E< 7.10	E< 6.40	ND< 0.91

4.2.3 Trace Metals

This section presents the results of the trace metals tests. Metal analyses were performed on samples from three types of sample trains: a dedicated metals train, the total particulate trains, and a dedicated chromium train. Table 4-30 presents a summary of the metals emissions at the stack. More detailed results are presented in the following tables:

Table 4-31	Metals measured by metals train at stack on mixed fuel
Table 4-32	Metals measured by metals train at boiler exit on mixed fuel
Table 4-33	Metals measured by metals train at stack on commercial refuse
Table 4-34	Metals measured by metals train at boiler exit on commercial refuse
Table 4-35	Metals measured by particulate train on mixed fuel
Table 4-36	Metals measured by particulate train on commercial refuse
Table 4-37	Chromium measurements on commercial refuse

The results show that at the stack most metals were below the quantitation limit. Low levels of antimony, barium, boron, chrome, lead, manganese, mercury, and zinc were measured.

TABLE 4-30. SUMMARY OF METALS MEASUREMENTS AT COMMERCE.
(UG/NM3 CORRECTED TO 12% CO2)

	Mixed Fuel		Commercial refuse	
	Stack	Blr exit	Stack	Blr exit
	*********	*********	*********	*********
Aluminum	< 16.2	178,000	< 16.2	73,600
Antimony	0.29	822	0.33	2,621
Arsenic	< 0.16	78	< 0.08	76
Barium	117	4,700	< 116	< 2,382
Beryllium	< 0.19	6.88	< 0.17	3.81
Bismuth	0.16	31.4	< 0.02	28.9
Boron	344	3,320	555	2,216
Cadmium	2.0	1,680	0.4	1,050
Calcium	56	193,000	64	108,000
Cr (metals train)	2.4	3,620	< 0.31	627
Cr (chrome train)	N/A	N/A	0.24	931
Hexavalent Chromium	N/A	N/A	< 0.42	20.8
Cobalt	< 0.34	111	< 0.11	88
Copper	< 54	8,820	< 56.1	29,200
Indium	< 0.27	< 23	< 0.16	< 0.65
Iron	< 54	84,200	< 133	46,600
Lead	1.97	18,100	3.22	17,200
Magnesium	< 270	88,900	< 543	< 46,600
Manganese	0.96	3,240	1.46	1,870
Mercury	41.4	475	75.8	287
Molybdenum	< 12.5	522	< 11.8	< 745
Nickel	6.3	4,200	< 0.28	2,080
Phosphorus	< 10,800	8.73E06	< 10,800	1.9E06
Potassium	< 38.9	202,000	< 35.4	73,000
Selenium	< 2.72	< 84	< 2.52	55
Silicon	66	1,864	55	187
Sodium	< 38.9	114,700	< 35.4	76,200
Tin	< 2	800	< 2	254
Vanadium	< 0.09	257	< 0.25	65
Zinc	38.5	90,900	35	83,400

Note: Data from Test 18 not included in stack average for commercial refuse due to baghouse leak during test.

TABLE 4-31. METALS MEASURED BY METALS TRAIN AT STACK, MIXED FUEL.

Test No.	3-Stack ug/Nm3 @12% CO2 *********	5-Stack ug/Nm3 @12% CO2 *********	9-Stack ug/Nm3 @12% CO2 *********	Average ug/Nm3 @12% CO2 *********	Average lb/hr *****
Aluminum	< 16.1	< 16.4	< 16.1	< 16.2	< 0.0026
Antimony	0.54	0.16	0.16	0.29	0.00005
Arsenic	0.02	< 0.02	0.45	< 0.16	< 0.00003
Barium	103	137	112	117	0.0190
Bismuth	0.41	0.04	0.04	0.16	0.00003
Boron	182	219	632	344	0.0554
Cadmium	0.6	0.4	4.9	2.0	0.00032
Calcium	20	21	127	56	0.0090
Chromium	3.2	1.5	2.3	2.33	0.00038
Cobalt	0.16	0.44	0.43	0.34	0.00006
Copper	< 53.6	< 54.8	< 53.5	< 54.0	< 0.0087
Indium	< 0.16	0.49	< 0.16	< 0.27	< 0.00004
Iron	< 54	< 54.8	< 53.5	< 54.1	< 0.0087
Lead	1.61	0.55	3.75	1.97	0.00032
Magnesium	< 268	< 274	< 268	< 270	< 0.0436
Manganese	1.45	0.99	0.43	0.96	0.00016
Mercury	38.7	42.4	43.2	41.4	0.0067
Molybdenum	< 12.1	< 13	< 12.3	< 12.5	< 0.0020
Nickel	1.8	0.66	16.5	6.3	0.0010
Phosphorus	< 10,700	< 10,960	< 10,700	< 10,787	< 1.75
Selenium	< 2.68	< 2.81	< 2.68	< 2.72	< 0.00044
Silicon	52	54	92	66	0.0107
Tin	< 2	< 2	< 2	< 2	< 0.0003
Vanadium	< 0.11	< 0.05	< 0.11	< 0.09	< 0.00001
Zinc	40.3	34.6	40.7	38.5	0.0062

TABLE 4-32. METALS MEASURED BY METALS TRAIN AT BOILER EXIT, MIXED FUEL.

Test No.	3-Inlet ug/Nm3 @ 12% CO2 *********	5-Inlet ug/Nm3 @ 12% CO2 *********	9-Inlet ug/Nm3 @ 12% CO2 *********	Average ug/Nm3 @ 12% CO2 *********	lb/hr *****
Aluminum	213,000	157,000	164,000	178,000	26.5
Antimony	1,112	381	974	822	0.12
Arsenic	88	59	87	78	0.012
Barium	8,455	2,795	2,835	4,695	0.71
Bismuth	16.2	25.5	52.6	31.4	0.0047
Boron	3,287	4,007	2,669	3,321	0.49
Cadmium	1,480	2,000	1,550	1,680	0.25
Calcium	364,000	18,600	198,000	193,500	29.5
Chromium	7,530	1,330	1,990	3,620	0.55
Cobalt	174	72	88	111	0.017
Copper	7,130	14,500	4,824	8,818	1.29
Indium	< 10	56	< 1	< 23	< .003
Iron	120,000	74,700	57,800	84,167	12.6
Lead	4,298	26,100	24,000	18,133	2.65
Magnesium	83,900	39,900	143,000	88,933	13.3
Manganese	3,964	3,363	2,377	3,235	0.48
Mercury	712	351	361	475	0.071
Molybdenum	1,163	216	186	522	0.079
Nickel	10,300	1,980	415	4,240	0.65
Phosphorus	1.29E+07	3.59E+06	9.71E+06	8.73E+06	1,318
Selenium	< 180	35	36	< 84	< .0127
Silicon	3,670	482	1,440	1,860	0.28
Tin	1,360	321	726	800	0.12
Vanadium	349	294	127	257	0.038
Zinc	144,000	58,900	69,900	90,933	13.7

TABLE 4-33. METALS MEASURED BY METALS TRAIN AT STACK, COMMERCIAL REFUSE.

Test No.	13-Stack ug/Nm3 @12% CO2 *********	16-Stack ug/Nm3 @12% CO2 *********	29-Stack ug/Nm3 @12% CO2 *********	18-Stack ug/Nm3 @12% CO2 *********	Average ug/Nm3 @12% CO2 *********	Average lb/hr *****
Aluminum	< 16.1	< 15.8	< 16.7	168	< 16.2	< 0.0026
Antimony	0.11	0.16	0.72	0.1	0.33	0.00005
Arsenic	< 0.02	0.19	< 0.02	1.38	< 0.08	< 0.00001
Barium	< 107	124	< 116	< 221	< 116	< 0.0188
Bismuth	0.02	< 0.02	0.02	0.17	< 0.02	< 0.00001
Boron	339	781	546	459	555	0.0904
Cadmium	0.5	0.3	0.4	18	0.4	0.00006
Calcium	45	26	121	3,000	64	0.010
Chromium	0.54	0.36	< 0.02	3.63	< 0.31	< 0.00005
Cobalt	0.11	0.16	< 0.06	< 0.52	< 0.11	< 0.00002
Copper	60	< 52.7	< 55.7	< 52.2	< 56.1	< 0.0091
Indium	< 0.16	< 0.16	< 0.17	< 0.16	< 0.16	< 0.00003
Iron	176	< 52.7	171	< 52.2	< 133	< 0.0215
Lead	4.84	3.16	1.67	365	3.22	0.00053
Magnesium	288	< 1055	287	< 792	< 543	< 0.0890
Manganese	0.11	0.42	3.84	4.96	1.46	0.00023
Mercury	56.7	85.7	85	30.6	75.8	0.0123
Molybdenum	< 10.5	< 11.9	< 12.9	< 15.7	< 11.8	< 0.0019
Nickel	< 0.02	0.46	0.36	2.6	< 0.28	< 0.00005
Phosphorus	< 10760	< 10550	< 11130	< 10400	< 10,813	< 1.76
Selenium	< 2.54	< 2.17	< 2.85	< 4.17	< 2.52	< 0.00041
Silicon	67	68	31	< 2	55	0.009
Tin	< 2	< 2	< 2	14	< 2	< 0.0004
Vanadium	0.59	< 0.05	< 0.11	< 0.05	< 0.25	< 0.00004
Zinc	33.8	35.4	35.8	1330	35.0	0.0057

Note-Test 18 not included in averages due to baghouse leak.

TABLE 4-34. METALS MEASURED BY METALS TRAIN AT BOILER EXIT, COMMERCIAL REFUSE.

Test No.	13-Inlet ug/Nm3 @12% CO2 *********	16-Inlet ug/Nm3 @12% CO2 *********	29-Inlet ug/Nm3 @12% CO2 *********	18-Inlet ug/Nm3 @12% CO2 *********	Average ug/Nm3 @12% CO2 *********	Average lb/hr *****
Aluminum	N/A	138,000	39,100	43,700	73,600	13.8
Antimony	693	857	446	8,488	2,621	0.43
Arsenic	2.7	112	96	92	76	0.014
Barium	< 1,541	1,480	1,535	< 4,973	< 2,382	< 0.41
Bismuth	5.6	29.8	48.1	32.2	28.9	0.0052
Boron	1,980	2,898	2,209	1,778	2,216	0.38
Cadmium	1,440	20	1,390	1,330	1,045	0.17
Calcium	14,000	208,000	132,000	76,400	107,600	19.8
Chromium	618	546	316	1,027	627	0.107
Cobalt	77	188	46	42	88	0.015
Copper	N/A	76,000	3,853	7,599	29,151	5.48
Indium	< 0.67	< 0.88	< 0.49	< 0.57	< 0.65	< 0.0001
Iron	59,300	90,300	28,300	37,800	53,925	9.37
Lead	7,648	25,800	15,000	20,400	17,212	3.09
Magnesium	N/A	< 88,300	< 3,296	< 48,200	< 46,599	< 8.81
Manganese	N/A	3,203	970	1,428	1,867	0.35
Mercury	312	184	332	321	287	0.049
Molybdenum	401	1,327	309	< 941	< 745	< 0.13
Nickel	2,240	4,140	1,400	540	2,080	0.37
Phosphorus	2.99E+06	2.92E+06	906,000	870,000	1.92E+06	326
Selenium	28.6	28.8	37.6	123	55	0.0095
Silicon	306	< 7	338	96	187	0.031
Tin	< 9	< 7	771	227	254	0.045
Vanadium	N/A	94	67	36	65	0.012
Zinc	59500	79,790	71,700	122,600	83,398	14.5

TABLE 4-35. BERYLLIUM, SODIUM, AND POTASSIUM RESULTS ON MIXED FUEL.

Test No. ********	Beryllium *********	Potassium *********	Sodium ******
ug/Nm3 @ 12% CO2:			
2-Stack	< 0.18	< 36.9	< 36.9
7-Stack	0.17	< 33.1	< 33.1
11-Stack	< 0.22	< 46.0	< 46.0
Stack avg.	< 0.19	< 38.9	< 38.9
ug/Nm3 @ 12% CO2:			
2-Inlet	15.2	323,000	144,000
7-Inlet	0.69	127,000	92,100
11-Inlet	4.75	157,000	108,000
Inlet avg.	6.88	202,000	114,700
Mass emissions, lb/hr:			
Stack avg.	< 0.00003	<0.0059	<0.0059
Inlet avg.	0.00107	31.6	18.0

TABLE 4-36. BERYLLIUM, SODIUM, AND POTASSIUM RESULTS ON COMMERCIAL REFUSE.

Test No. ********	Beryllium *********	Potassium *********	Sodium ******
ug/Nm3 @ 12% CO2:			
14-Stack	< 0.15	< 32.6	< 32.6
21-Stack	< 0.19	< 38.6	< 38.6
27-Stack	< 0.18	< 35.0	< 35.0
Stack avg.	< 0.17	< 35.4	< 35.4
ug/Nm3 @ 12% CO2:			
14-Inlet	5.40	94,800	99,500
21-Inlet	2.94	53,800	43,600
27-Inlet	3.08	70,300	85,500
Inlet avg.	3.81	73,000	76,200
Mass emissions, lb/hr:			
Stack avg.	< 0.00003	< 0.0056	< 0.0056
Inlet avg.	0.00062	11.91	12.45

TABLE 4-37. RESULTS OF DEDICATED CHROMIUM TRAIN TESTS ON COMMERCIAL REFUSE.

Test No. ********	Total Chromium *********	Hexavalent Chromium **********
ug/Nm3 @ 12% CO2:		
23-Stack	0.47	< 0.43
25-Stack	< 0.04	< 0.41
26-Stack	0.21	< 0.43
Stack avg.	0.24	< 0.42
ug/Nm3 @ 12% CO2:		
23-Inlet	4.47	24.1
25-Inlet	909	17.5
26-Inlet	953	5.8
Inlet avg.	931	20.8
Mass emissions, lb/hr:		
Stack avg.	0.00004	< 0.00007
Inlet avg.	0.156	0.0037

Notes:

1. Test 23 not included in inlet total chromium average due to suspicious result.
2. Test 26 not included in inlet hex chrome average due to color interference during analysis.

4.2.4 Volatile Organic Species

Samples for trace volatile hydrocarbon analysis were collected in Tedlar bags at the boiler exit and stack. Triplicate samples were collected at each location on each of the two test fuels.

The samples were analyzed two ways. First, gas chromatography with a Hall electron capture detector (ECD) and a photoionization detector was used. This method provided very low detection levels (<0.1 ppb) for ten target compounds. Second, a GC/MS scan per EPA Method 8240 was performed. This procedure provides concentration values for 41 species, with detection limits of 3 to 30 ppb.

The results of the GC/ECD and PID tests are presented in Tables 4-38 and 4-39 for the residential/commercial mix and commercial fuels, respectively. The results show that all species were present at or below their detection limits of 0.1 to 0.22 ppb for both fuels. There were no significant differences between results at the boiler exit and stack.

No detectable levels were measured for any species on the GC/MS scan. A list of species and the detection limits are presented in Table 4-40.

TABLE 4-38. TRACE VOLATILE HYDROCARBONS WHILE FIRING RESIDENTIAL/COMMERCIAL MIX

Species	Boiler exit, ppb	Stack	
		ppb	lb/hr
Vinyl chloride	ND <0.12	ND <0.22	ND $<6.8 \times 10^{-5}$
Methylene chloride	ND <0.1	ND <0.1	ND $<7.7 \times 10^{-5}$
Chloroform	ND <0.1	ND <0.1	ND $<1.1 \times 10^{-4}$
1,2-Dichloroethane	ND <0.1	ND <0.1	ND $<9.0 \times 10^{-5}$
1,1,1-Trichloroethane	ND <0.14	ND <0.17	ND $<1.7 \times 10^{-4}$
Carbon tetrachloride	ND <0.1	ND <0.1	ND $<1.4 \times 10^{-4}$
Trichloroethylene	ND <0.1	ND <0.1	ND $<1.2 \times 10^{-4}$
Ethylene bromide	ND <0.1	ND <0.1	ND $<1.7 \times 10^{-4}$
Tetrachloroethylene	ND <0.1	ND <0.1	ND $<1.5 \times 10^{-4}$
Benezene	ND <0.17	ND <0.1	ND $<1.2 \times 10^{-4}$
Total	ND <1.1	ND <1.2	ND <.0012

NOTES:

1. These results obtained using GC/ECD and GC/PID
2. There were no unidentified peaks, implying (but not proving) the absence of similar halocarbons at 0.1 ppb.
3. No measurable levels were detected for any species on the blank sample.
4. A GC/MS scan was also done for 41 compounds. See Table 4-40 for a list of compounds and detection limits.

TABLE 4-39. TRACE VOLATILE HYDROCARBONS WHILE FIRING COMMERCIAL REFUSE

Species	Boiler exit, ppb	Stack	
		ppb	lb/hr
Vinyl chloride	ND <0.1	ND <0.22	ND $<5.7 \times 10^{-5}$
Methylene chloride	ND <0.1	ND <0.1	ND $<7.7 \times 10^{-5}$
Chloroform	ND <0.1	ND <0.1	ND $<1.1 \times 10^{-4}$
1,2-Dichloroethane	ND <0.1	ND <0.1	ND $<9.0 \times 10^{-5}$
1,1,1-Trichloroethane	ND <0.1	ND <0.17	ND $<1.2 \times 10^{-4}$
Carbon tetrachloride	ND <0.1	ND <0.1	ND $<1.4 \times 10^{-4}$
Trichloroethylene	ND <0.1	ND <0.1	ND $<1.2 \times 10^{-4}$
Ethylene bromide	ND <0.1	ND <0.1	ND $<1.7 \times 10^{-4}$
Tetrachloroethylene	ND <0.1	ND <0.1	ND $<1.5 \times 10^{-4}$
Benezene	ND <0.1	ND <0.1	ND $<1.2 \times 10^{-5}$
Total	ND <1.1	ND <1.2	ND <.0012

NOTES:

1. These results obtained using GC/ECD and GC/PID
2. There were no unidentified peaks, implying (but not proving) the absence of similar halocarbons at 0.1 ppb.
3. No measurable levels were detected for any species on the blank sample.
4. A GC/MS scan was also done for 41 compounds. See Table 4-40 for a list of compounds and detection limits.

TABLE 4-40. DETECTION LIMITS FOR TRACE VOLATILE HYDROCARBONS BY GC/MS SCAN. NO SPECIES WERE DETECTED ON ANY SAMPLE

	ppb
Chloromethane	3
Bromomethane	3
Vinyl Chloride	3
Chloroethane	3
Methylene Chloride	3
Acetone	3
Carbon Disulfide	3
Trichlorofluoromethane	3
1,1-Dichloroethene	3
1,1-Dichloroethane	3
trans-1,2-Dichloroethene	3
Chloroform	3
1,2-Dichloroethane	3
2-Butanone	3
1,1,1-Trichloroethane	3
Carbon Tetrachloride	3
Vinyl Acetate	3
Bromodichloromethane	3
1,2-Dichloropropane	3
cis-1,3-Dichloropropene	3
Trichloroethene	3
Benzene	12
Chlorodibromomethane	12
trans-1,3-Dichloropropene	12
1,1,2-Trichloropropane	12
2-Chloroethoxy ethene	12
Bromoform	12
4-Methyl-2-Pentanone	12
2-Hexanone	12
Tetrachloroethene	12
1,1,2,2-Tetrachloroethane	12
Toluene	30
Chlorobenzene	30
Ethyl Benzene	30
Styrene	30
m-Xylene	30
p&o-Xylene	30
1,3-Dichlorobenzene	30
1,2-Dichlorobenzene	30
1,4-Dichlorobenzene	30
Chlorophenols	30

4.2.5 Formaldehyde

The results of the formaldehyde tests are presented in Table 4-41. Formaldehyde tests were performed on commercial refuse only. The results show that formaldehyde concentration were barely above the field blank/ambient level of .016 ppm for two of the three test runs. For Test 26B, a level of 0.2 ppm was measured.

TABLE 4-41. RESULTS OF FORMALDEHYDE TESTS ON COMMERCIAL REFUSE

Test No	26A	26B	28A	Average	Field Blank
Date	8/3	8/3	8/4		8/4
Time	1500-1550	1635-1735	1505-1605		
Formaldehyde:					
ppm	.022	.20	.016	.079	..016
ppm at 3% O_2	.036	.30	.024	.120	--
lb/hr	.0058	.051	.0043	.0204	.0042

4.2.6 Nitrosamines

The results of the nitrosamine tests are presented in Tables 4-42 and 4-43. No detectable levels of nitrosamines were found on any of the samples.

4.2.7 Acid Gases

The results of the HCl and HF tests are presented in Table 4-44 for mixed refuse and Table 4-45 for commercial refuse. HCl emissions at the stack averaged 8 ppm at 3% O_2, and HF emissions at the stack averaged 0.1 ppm. The removal efficiency of the quench reactor baghouse system was 99.0% for HCl and 98.9% for HF.

TABLE 4-42. NITROSAMINE RESULTS ON COMMERCIAL/RESIDENTIAL MIX

Stack

Test	9A	10A	10B	Avg.
ug/train	ND <.28	ND <.28	ND <.28	ND <.28
ug/Nm^3 @ 12% CO_2	ND <9.1	ND <6.7	ND <8.5	ND <8.1
lb/hr	ND <1.5 x 10^{-3}	ND <1.0 x 10^{-3}	ND <1.1 x 10^{-3}	ND <1.2

Boiler Exit

Test	9A	10A	10B	Avg.
ug/train	ND <.27	ND <.28	ND <.25	ND <.27
ug/Nm^3 @ 12% CO_2	ND <5.1	ND <3.7	ND <4.4	ND <4.4
lb/hr	ND <7.0 x 10^{-4}	ND <5.6 x 10^{-4}	ND <6.6 x 10^{-4}	ND <6.4 x 1

TABLE 4-43. NITROSAMINE RESULTS ON COMMERCIAL FUEL

Stack

Test	12A	12B	12C	Avg.
ug/train	ND <.30	ND <.31	ND <.30	ND <.31
ug/Nm^3 @ 12% CO_2	ND <4.3	ND <3.6	ND <3.7	ND <3.9
lb/hr	ND <7.3 x 10^{-4}	ND <6.3 x 10^{-4}	ND <5.9 x 10^{-4}	ND <6.5

Boiler Exit

Test	12A	12B	12C	Avg.
ug/train	ND <.29	ND <.28	ND <.32	ND <.30
ug/Nm^3 @ 12% CO_2	ND <3.2	ND <3.1	ND <3.5	ND <3.3
lb/hr	ND <5.0 x 10^{-4}	ND <4.8 x 10^{-4}	ND <5.4 x 10^{-4}	ND <5.0 x 1(

TABLE 4-44. HCl AND HF EMISSIONS AT BOILER EXIT AND STACK FIRING RESIDENTIAL/COMMERCIAL MIX

Location		Boiler Exhaust				Stack				Removal Eff.
Test		2	7	11	Avg.	2	7	11	Avg.	Avg.
HCl	ppm	671	378	688	579	5.4	5.8	6.5	5.9	
	ppm @ 3% O_2	984	534	976	831	9.0	9.0	10.3	9.4	
	lb/hr	196	105	201	167	1.8	1.7	2.0	1.8	98.9
HF	ppm	3.22	3.96	5.99	4.39	0.11	0.063	0.047	0.073	
	ppm @ 3% O_2	4.72	5.60	8.49	6.27	0.18	0.097	0.074	0.12	
	lb/hr	.52	.61	.97	.71	.021	.010	.0082	0.013	98.8

TABLE 4-45. HCl AND HF EMISSIONS AT BOILER EXIT AND STACK FIRING COMMERCIAL FUEL

Location		Boiler Exhaust				Stack				Removal Eff.
Test		14	21	27	Avg.	14	21	27	Avg.	Avg.
HCl	ppm	564	249	695	503	7.6	2.6	3.3	4.5	
	ppm @ 3% O_2	807	341	910	686	11.4	4.1	5.6	7.0	
	lb/hr	165	67	184	139	2.37	0.80	1.05	1.41	99.0
HF	ppm	2.74	5.86	8.67	5.75	.036	.036	.087	.53	
	ppm @ 3% O_2	3.92	8.03	11.35	6.46	.054	.057	.15	.087	
	lb/hr	.44	.87	1.27	.86	.0061	.0060	.0154	.0092	98.9

APPENDIX A

MEASUREMENT PROCEDURES - GENERAL DESCRIPTIONS

Continuous Emissions Monitoring System

Oxygen (O_2) by Continuous Analyzer

Carbon Dioxide (CO_2) by Continuous Analyzer

NO/NOx by Continuous Analyzer

Carbon Monoxide (CO) by Continuous Analyzer (TECO)

Sulfur Dioxide (SO_2) by Continuous Analyzer

Total Particulate by EPA Method 5, with Condensible Analysis

Sulfur Oxides by SCAQMD Procedures

Hydrocarbons by SCAQMD TCA Method

Determination of Moisture in Stack Gases

Semi-Volatile Organic Sampling Train Procedures

Flow Chart for Semi-VOST Analyses

Continuous Emissions Monitoring System

O_2, CO, CO_2, NO, NOx, and SO_2 are measured using an extractive continuous emissions monitoring (CEM) package, shown in the following figure. This package is comprised of three basic subsystems. They are: (1) the sample acquisition and conditioning system, (2) the calibration gas system, and (3) the analyzers themselves. This section presents a description of the sampling and calibration systems. Descriptions of the analyzers used in this program and the corresponding reference test methods follow. Information regarding quality assurance information on the system, including calibration routines and system performance data follows.

The sample acquisition and conditioning system contains components to extract a representative sample from the stack or flue, transport the sample to the analyzers, and remove moisture and particulate material from the sample. In addition to performing the tasks above, the system must preserve the measured species and deliver the sample for analysis intact. The sample acquisition system extracts the sample through a stainless steel probe. The probe is insulated or heated as necessary to avoid condensation. If the particulate loading in the stack is high, a sintered stainless steel filter is used on the end of the probe.

Where water soluble NO_2 and/or SO_2 are to be measured, the sample is drawn from the probe through a heated Teflon sample line into a supercooled (approximately -20 °C) water removal trap. The trap consists of stainless steel flasks in a bath of dry ice and antifreeze. If dry ice is not locally available, ice and rock salt are used. This design removes the water vapor by condensation and freezes the liquid quickly. The contact between the sample and liquid water is minimized. Since the solubility of the NO_2 and SO_2 in ice is negligible, these species are conserved. This system meets the requirements of EPA Method 20. The sample is then drawn through a Teflon transport line and particulate filter, into the sample pump. The pump is a dual head, diaphragm pump. All sample-wetted components of the pump are stainless steel or Teflon. The pressurized sample leaving the pump flows through a stainless steel refrigerated (38 °F) compressed air dryer for final moisture removal. A drain line and valve are provided to constantly expel any condensed moisture from the dryer. After the dryer, the sample is directed into a distribution manifold. Excess sample is vented through a back-pressure regulator, maintaining a constant pressure of 5-6 psig to the analyzers.

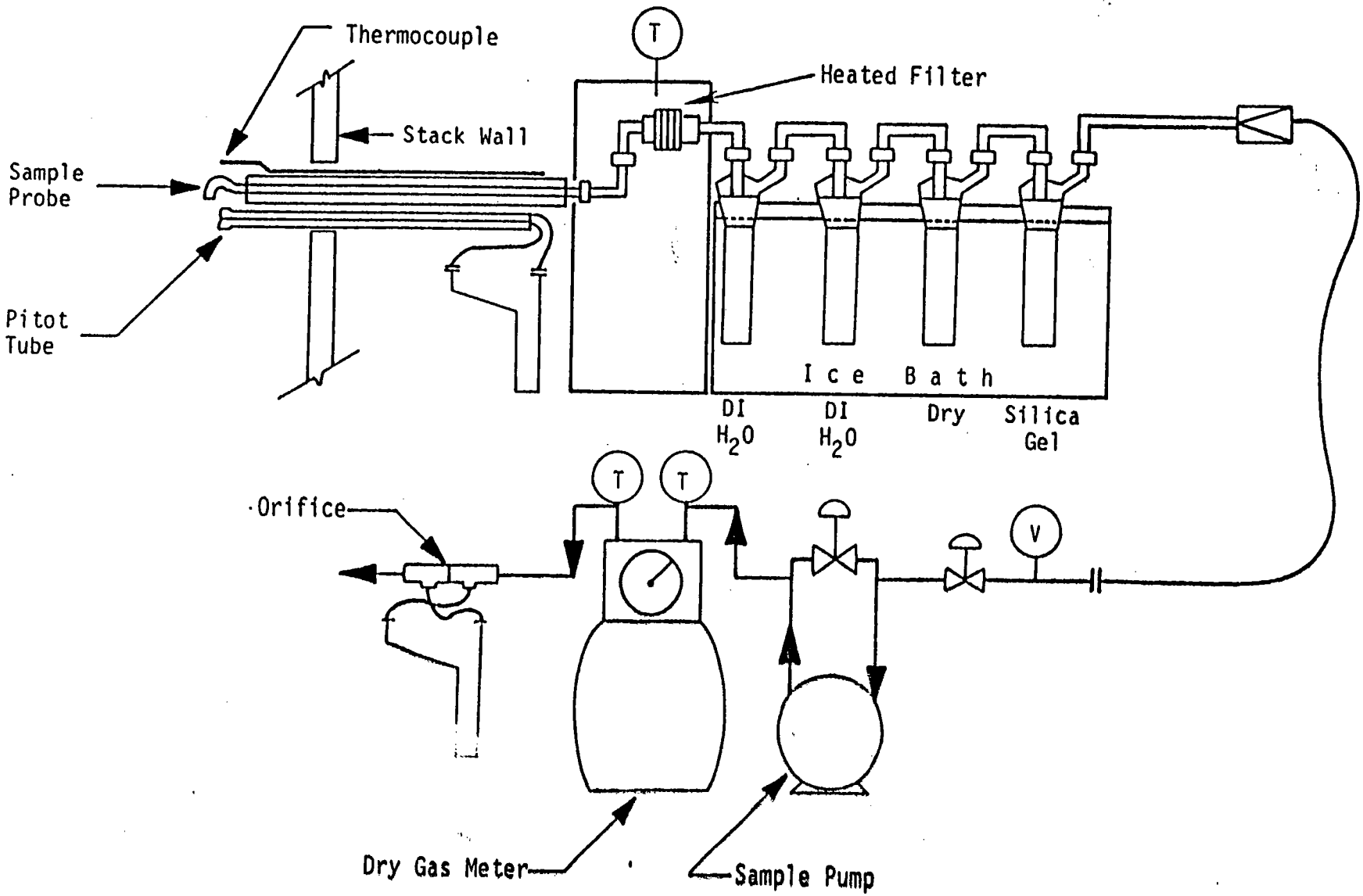
The calibration system is comprised of two parts: the analyzer calibration, and the system calibration check (dynamic calibration). The analyzer calibration equipment includes pressurized cylinders of certified span gas. The gases used are, as a minimum, certified to ±1% by the manufacturer where necessary, to comply with reference method requirements. EPA Protocol 1 gases are used. The cylinders are equipped with pressure regulators which supply the calibration gas to the analyzers at the same pressure and flow rate as the sample. The selection of zero, span, or sample gas directed to each analyzer is accomplished by operation of the sample/calibration selector valves.

The system calibration check is accomplished by transporting the same gases used to zero and span the analyzers to the sample conditioner inlet (probe exit). The span gas is exposed to the same elements as the sample and the system response is documented. Where the supercooled moisture removal system is used, water is added to the knockout flasks before the pre-test check. The analyzer indications for the system calibration check must agree within 3% of the analyzer calibration. Values are adjusted and changes/ repairs are made to the system to compensate for any difference in analyzer readings. Specific information on the analytical equipment and test methods used is provided in the following pages.

Method:	Carbon Dioxide (CO_2) by Continuous Analyzer
Applicable Ref. Methods:	EPA 3A, ARB 1-100, BA ST-5
Principle:	A sample is continuously drawn from the flue gas stream, conditioned, and conveyed to the instrument for direct readout of CO_2 concentration.
Analyzer:	Horiba PIR 2000
Measurement Principle:	Nondispersive infrared (NDIR)
Accuracy:	±1% of full scale
Ranges:	0-5, 0-10, 0-25%
Output:	0-10 mV
Interferences:	A possible interference includes water.
Response Time:	1.2 seconds
Sampling Procedure:	A representative flue gas sample is collected and conditioned using the CEM system described previously. Sample point selection is as described in the report.
Analytical Procedure:	Carbon dioxide concentrations are measured by short pathlength nondispersive infrared analyzers. These instruments measure the differential in infrared energy absorbed from energy beams passed through a reference cell (containing a gas selected to have minimal absorption of infrared energy in the wavelength absorbed by the gas component of interest) and a sample cell through which the sample gas flows continuously. The differential absorption appears as a reading on a scale of 0 to 100%.

When NO_2 is expected to be present in the flue gas, a supercooled water drop-out flask will be placed in the sample line to avoid loss of NO_2. Since NO_2 is highly soluble in water, "freezing out" the water will allow the NO_2 to reach the analyzers for analysis. The analyzer measures NO only. In the NOx mode, the gas is passed through a moly converter which converts NO_2 to NO and a total NOx measurement is obtained. NO_2 is determined as the difference between NO and NOx. Use of a moly converter instead of a stainless steel converter eliminates NH_3 interference; NH_3 is converted to NO with a stainless converter, but not with a moly converter.

Comparison to Other Methods: Use of this method with the CO_2 and H_2O interference corrections has yielded results within 1% of instrument scale when compared to simultaneous tests performed using the SCAQMD TCA method.



Sample Train for Determination of Total Particulate by EPA Method 5
with Condensible Analysis

Method:	Sulfur Oxides by SCAQMD Procedures
Reference:	SCAQMD Source Testing Manual, September 1977
Principle:	A metered flue gas sample is drawn through a glass probe, a temperature-controlled filter to collect sulfuric acid mist, followed by a series of impingers to collect sulfur trioxide and sulfur dioxide.
Sampling Procedure:	The sample train used in the tests is shown on the following figure. Sulfuric acid mist is collected on the filter, sulfur trioxide is collected in an optional impinger containing isopropyl alcohol, and sulfur dioxide is absorbed and oxidized to sulfuric acid in the second and third impingers. The fourth impinger contains silica gel. Unless a significant fraction of the sulfur oxides is present as sulfuric acid mist, isokinetic sampling is not required. If isokinetic sampling is required, a multiple-point collection shall be made. Proportional sampling will be necessary, however, when the fluctuation in gas flow and composition vary with time by more than 20%. Following a leak check, a one-hour sample is drawn through the train at a rate of 0.5 to 1.0 CFM. At five-minute intervals, the following data is recorded: sample point location, clock time, gas meter volume reading, inlet and outlet gas meter temperatures, and pressure differential of the flow rate orifice. During sampling, the filter temperature is maintained at 180 to 200 °F, and the filter temperature is recorded.
Sample Recovery and Analysis:	Sample recovery involves weighing the impingers to determine stack gas moisture content, and recovering the following samples for sulfur oxide analysis: 1. Probe wash and filter (sulfuric acid mist) 2. IPA impinger and back-up filter (SO_3, optional) 3. H_2O_2 impingers (SO_2) Each sample is titrated by acid base titration to determine acid sulfate content. If interfering species are present, barium chloride titration as specified in EPA Method 8 is performed. When this method is used in conjunction with SCAQMD total particulate testing, the sulfuric acid mist fraction is calculated as $H_2SO_4 \cdot 2H_2O$ and added to the particulate catch.

Method:	Hydrocarbons by SCAQMD Total Carbon Analysis (TCA) Method
Reference:	A. E. Salo, et. al, "Total Combustion Analysis: A Test Method for Measuring Organic Carbon, Carbon Monoxide, and Carbon Dioxide in a Solvent Effluent Control Program," County of Los Angeles Air Pollution Control District, 1974.
Principle:	An evacuated tank, preceded by a cold trap immersed in dry ice, is filled with flue gas at a constant rate. The tank contents are analyzed by gas chromatography for CO, CH_4, CO_2, and nonmethane hydrocarbons. The trap contents are analyzed separately for condensible hydrocarbons by combustion and measurement of CO_2.
Sampling Procedure:	A sample is collected at the source (usually from a stack or vent) into an evacuated tank preceded by a cold trap immersed in dry ice. The flow rate is regulated so that it is contant and the period sampled is one hour if possible. Pitot and temperature measurements of the total stack or vent flow are made. During sample collection, the lighter components pass as gases through the trap into the tank. Heavier components condense as liquid and solids in the trap.
Analytical Procedure:	In the analytical phase, tank and trap contents are processed separately. Refer to the attached flow diagram on the course of a TCA sample to the strip chart recorder. Gaseous carbon compounds from the tank are fractioned on a chromatographic column, eluting in the order: carbon monoxide, methane, carbon dioxide. Carrier-gas flow is then reversed and organic compounds other than methane are eluted off of the column as "back flush". All resulting vapors are passed through oxidizers where they are converted to carbon dioxide and measured by nondispersive infrared detectors. ESA subcontracts TCA analysis to qualified local laboratories experienced in the analytical procedures. These laboratories also supply the tanks for sampling.

Method:	Determination of Moisture in Stack Gases
Applicable Ref. Methods:	EPA 4, ARB 1-4
Principle:	A gas sample is extracted at a constant rate from the source; moisture is removed from the sample stream and determined volumetrically or gravimetrically.
Sampling Procedure:	The sample train used in the tests is shown in the following figure. The sample is drawn at a constant rate through a stainless steel probe. The probe is connected to an impinger train by Teflon tubing. The train consists of two Smith-Greenburg impingers which contain 100 ml water, an empty impinger as a knockout, and an impinger containing silica gel to protect the pump from moisture.
Sample Recovery and Analysis	Following testing, moisture content is determined gravimetrically from initial and final impinger weights.

Method: Semi-volatile Organic Sampling Train (Semi-VOST)

References: CARB Method 428 (for dioxins/furans)
Draft CARB Method 429 (for PAH)
ASME Modified Method 5

Principle: A metered flue gas sample is collected isokinetically, and semi-volatile organic compounds are collected on a heated filter, on water-cooled XAD-2 resin module, and in an iced impinger bath. Depending upon the specific test requirements, the samples are then analyzed for such species as polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDD/PCDF), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), and chlorobenzenes and chlorophenols. This section discusses the sampling and sample handling techniques for the semi-VOST method. Analytical procedures vary significantly for different projects and target compounds, and are discussed in the text of the report.

Sample Train Preparation: Because of the very low detection limits of the analytical techniques, thorough cleaning of sample train components prior to testing is vital. Prior to testing, all glassware is cleaned in ESA's laboratory with high purity water, acetone, and hexane rinses, and then baked at high temperature. Resin modules are cleaned and loaded with purified resin by the contract laboratory within one week of the scheduled test date. Batches of Whatman 934AH fiberglass filters are toluene-rinsed and proofed by the contract laboratory. Individual filters are then tared and stored in petri dishes lined with hexane rinsed aluminum foil.

Sample train assembly is performed in an on-site clean room by experienced personnel.

Sampling: The sample train is shown in the attached figure. Sample is pulled through the following components:

1. Glass or nickel-coated stainless steel nozzle
2. Heated glass probe (250 ± 15°F)
3. Optional cyclone in heated oven (250 ± 15°F)
4. Filter in heated oven
5. Glass or teflon tubing
6. Condenser/sorbent module cooled with circulating ice water from impinger bath
7. Dry impinger with stub stem
8. Smith-Greenburg impinger with 100 ml DI H_2O
9. Dry impinger as a knockout
10. Impinger containing silica gel
11. Leak-free vacuum pump
12. Calibrated dry gas meter

The pump, meter, manometers, and heater controllers are all contained in a single control box (Andersen Universal or equivalent).

During final sample train assembly and leak check procedures on the stack or duct, special precautions are taken to minimize the chance of contamination. Sample train components are open to the air for as short a time as possible; and during transport to and from the stack, all components are sealed with hexane rinsed aluminum foil.

Sample Recovery: All sample recovery is performed in ESA's laboratory or an on-site clean room. Following sampling the resin module is sealed with glass caps and stored in a refrigerator or ice chest, the filter is placed in a light-proofed petri dish, and all glassware components are rinsed. The rinse consists of three rinses each of distilled water, acetone, and hexane. All solvents are high purity GS/MC grade, the squirt bottles are teflon, and the sample bottles are amber glass with teflon-lined caps. Water fractions are placed in separate bottles from the acetone/hexane rinses to simplify extraction procedures for the contract laboratory.

Field Blank: At least once during each test series, a field blank sample is collected. This consists of assembling a sample train transporting it to and from the stack, leak checking it, and recovering it. This sample is analyzed using the same procedures as for the test samples.

Sample Custody: Full chain of custody is maintained on all reagents, sample trains, and samples by ESA and by contract laboratories. In addition to formal documentation by the sample custodians, sample data sheets are initialed by the individuals who assemble and recover each sample train component.